

WATER RESOURCES DEVELOPMENT PROJECT

PARK RIVER LOCAL PROTECTION

CONNECTICUT RIVER BASIN
HARTFORD, CONNECTICUT

DESIGN MEMORANDUM NO. 3

HYDRAULIC ANALYSIS



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

FEBRUARY 1975

DAEN-CWE-B (NEDED-W, 19 Feb 75) 1st Ind
SUBJECT: Park River Local Protection, Connecticut River
Basin, Hartford, Connecticut, Design Memo-
randum No. 3, Hydraulic Analysis

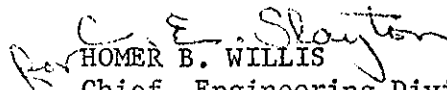
DA, Office of the Chief of Engineers, Washington, D.C. 20314 27 March 1975

TO: Division Engineer, New England, ATTN: NEDED-W

Approved.

FOR THE CHIEF OF ENGINEERS:

1 Incl
wd


HOMER B. WILLIS
Chief, Engineering Division
Directorate of Civil Works



DEPARTMENT OF THE ARMY
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REPLY TO
ATTENTION OF:

NEDED-W

19 February 1975

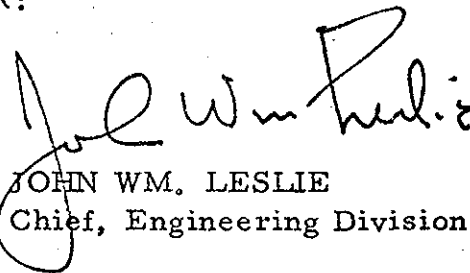
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HQDA (DAEN-CWE-B)
WASH DC 20314

1. In accordance with ER 1110-2-1150, the subject design memorandum is submitted for review and approval.
2. A supplement to this design memorandum describing the hydraulic analysis of a recently developed alternative alignment for the auxiliary conduit will be transmitted at a later date.

FOR THE DIVISION ENGINEER:

1 Incl (7 cys)
as


JOHN WM. LESLIE
Chief, Engineering Division

WATER RESOURCES DEVELOPMENT PROJECT

PARK RIVER
LOCAL PROTECTION
CONNECTICUT RIVER BASIN
HARTFORD, CONNECTICUT

DESIGN MEMORANDA INDEX

<u>Number</u>	<u>Title</u>	<u>Anticipated Submission Date</u>	<u>Date Submitted</u>	<u>Date Approved</u>
1	Hydrology		16 Feb 73	12 Apr 73
2	GDM - Phase I - Plan Formulation		30 Mar 73	16 Jul 73
2	GDM -Phase II - Project Design, Site Geology & Interior Drainage Part I - Box Conduit		30 Aug 74	18 Oct 74
2	GDM - Phase II - Project Design Part II - Auxiliary Conduit		24 Jan 75	
3	Hydraulic Analysis		19 Feb 75	
4	Concrete Materials Part I - Box Conduit	Apr 75		
5	Embankment & Foundations Part I - Box Conduit		7 Feb 75	
6	Pumping Stations		29 Nov 74	
7	Detailed Design of Structures Part I - Box Conduit		25 Oct 74	4 Dec 74

DESIGN MEMORANDA INDEX

<u>Number</u>	<u>Title</u>	<u>Anticipated Submission Date</u>	<u>Date Submitted</u>	<u>Date Approved</u>
8	Auxiliary Conduit Shafts Site Geology, Foundations & Detailed Design of Structures	Dec 75		
9	Auxiliary Conduit Tunnel Site Geology, Foundations, Concrete Materials & Detailed Design of Structures	Apr 76		

WATER RESOURCES DEVELOPMENT PROJECT

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DESIGN MEMORANDUM NO. 3

HYDRAULIC ANALYSIS

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WATER REOURCES DEVELOPMENT PROJECT

PARK RIVER LOCAL PROTECTION CONNECTICUT RIVER BASIN HARTFORD, CONNECTICUT

PERTINENT DATA

1. PROJECT PURPOSE: Flood Control
2. PROJECT LOCATION:

State	Connecticut
County	Hartford
City	Hartford
River	Park River
Basin	Connecticut River Basin
3. CLIMATE:

Mean Temperature	50.0° Fahrenheit
Mean Rainfall	42.38 inches
Mean Snowfall	43.8 inches
4. DRAINAGE AREAS:

Park River	78.3 square miles
North Branch	27.7 square miles
South Branch	47.0 square miles
5. FLOOD OF RECORD:

Park River at USGS gage sta.	14,000 cfs (August 1955)
North Branch at USGS gage sta.	10,000 cfs (August 1955)
South Branch at USGS gage sta.	5,000 cfs (August 1955)
6. RECORD STORM RAINFALL:

August 1955	9.47 inches (Hartford, 36 hrs)
-------------	--------------------------------
7. DESIGN STORM RAINFALL: 18.3 inches in 48 hours

8. DESIGN DISCHARGES:

(Concurrent Connecticut River Stage = 30 feet msl)

Park River Conduit	18,400 cfs
Auxiliary Conduit	5,400 cfs
North Branch Conduit	5,400 cfs
South Branch Conduit	18,400 cfs

9. CONDUIT DIMENSIONS:

	<u>Cross Section</u>	<u>Length</u>
Park River Conduit		
Section 2	Twin 34'-0" x 26'-6"	1,232 feet
Section 4	Twin 34'-0" x 26'-6"	1,323 feet
Auxiliary Conduit	22'-0" diameter	8,900 feet
North Branch Conduit		
Section 7	Twin 22'-0" x 25'-0"	1,065 feet
Section 9	Twin 22'-0" x 25'-0"	289 feet
South Branch Conduit		
Section 5	Twin 36'-0" x 27'-6"	125 feet

WATER RESOURCES DEVELOPMENT PROJECT

PARK RIVER LOCAL PROTECTION CONNECTICUT RIVER BASIN HARTFORD, CONNECTICUT

DESIGN MEMORANDUM NO. 3

HYDRAULIC ANALYSIS

1. PURPOSE

This memorandum presents the hydraulic criteria and analysis pertinent to the design of the conduits for the Park River Local Protection Project in Hartford, Connecticut. Included are the results of investigations and analyses, and descriptions of the hydraulic features.

2. AUTHORIZATION

The Park River project, substantially as presented in "Report on Review of Survey for Flood Control, Park River Basin, Connecticut," dated July 1966, was authorized by the Flood Control Act of 1968, Public Law 90-483.

3. EXISTING PROJECT

Construction of the Park River flood control project began in 1944. At that time, the plan for protection of Hartford included 5,600 feet of twin barrel pressure conduit on the Park River, two pumping stations and 3,100 feet of pressure conduit on Gully Brook. The original Park River conduit, hereinafter referred to as the lower main conduit, consists of two barrels, each 30 feet wide by 19.3 feet high and extends from Bushnell Park to the Connecticut River as shown on plate 3-1. Two pumping stations located at Keeney Lane and Bushnell Park serve to discharge interior drainage and are shown on plate 3-2.

During the 1960's, the Greater Hartford Flood Commission constructed about 7,000 feet of conduit along the Park River and its North and South Branches in conjunction with construction of an interstate highway. The size and length of these completed sections are as follows:

<u>Section</u>	<u>Size</u>		<u>Length</u> (feet)
	<u>Width by Height</u> (feet)		
1 (Park River)	Twin	34 x 26.5	1,213
3 (Park River)	Twin	34 x 26.5	1,710
6 (South Branch)	Twin	36 x 27.5	1,460
8 (North Branch)	Twin	22 x 25	2,760

The locations of these conduits are shown on plate 3-2.

4. MODIFICATIONS TO GDM - PHASE I

a. General. The plan of flood protection proposed in the GDM - Phase I consisted of construction of conduit sections 2, 4, 5, 7 and 9, a junction structure, an auxiliary conduit and two pumping stations. The design presented herein includes the following modifications to that plan: (1) construction of only 285 feet of section 9 with a weir at the entrance, (2) construction of a drop-down structure in the auxiliary conduit, (3) lowering the auxiliary conduit, and (4) construction of the Pope Park pumping station in lieu of the Riverside pumping station. More detailed information regarding these modifications was presented in GDM - Phase II, Part I - Box Conduit, with additional information to be provided in Part II - Auxiliary Conduit.

b. Section 9, North Branch conduit. Project economics have necessitated reduction in the length of section 9 from 935 to 285 feet. The conduit entrance will be located at a point about 100 feet upstream from Farmington Avenue with an entrance weir about 31 feet upstream from the headwall as shown on plate 3-5.

c. Auxiliary conduit. To improve conditions for tunnelling the conduit will be lowered to a flat gradient at elevation -14.0 feet msl. This requires construction of a dropdown (spillway) structure to provide a smooth grade change from the junction structure to the auxiliary conduit. The design of these features is presented in paragraph 8. Plan and profile views of the auxiliary are shown on plate 3-6.

5. DESIGN DISCHARGES

a. General. The conduits were analyzed hydraulically for two extreme conditions. The primary condition was that of the project design flood occurring with the Connecticut River at a stage of 30 feet msl, which corresponds to the 100-year frequency flood level as modified by existing upstream flood control reservoirs. For economic reasons, the ponding levels upstream from the North and South Branch conduits were limited to approximately elevation 52 feet msl. With this differential head of approximately 22 feet, the system will flow full and discharge 23,800 cfs, of which 5,400 cfs will flow in the auxiliary conduit. Further information regarding design discharge conditions is provided in Design Memorandum No. 1 - Hydrology and subsequent indorsements thereto.

The second condition investigated was the occurrence of total discharges in the main Park River conduit varying from 1,000 to 23,150 cfs with a coincident Connecticut River stage of 4 feet msl. The Connecticut River is tidal at the confluence with the Park River and this elevation is approximately 1 foot above mean high water. The purpose of this investigation was to determine maximum velocities and locations of hydraulic jumps. These conditions are discussed in paragraph 6b, Hydraulic Analysis.

b. Main Park River conduit. The original Park River conduit (lower main conduit) was designed for a discharge of 18,000 cfs with the Connecticut River at 26 feet msl and the Park River at elevation 44 feet msl at a headwall in Bushnell Park. Design study reports prepared by NED in 1940 state that the conduit was analyzed structurally for bursting pressure with the Connecticut River at elevation 42 feet msl. Under the new design conditions the lower main conduit will discharge 18,400 cfs and have a maximum pressure gradient at elevation 42 feet msl.

Gully Brook, a 2.4 square mile tributary of the Park River, discharges into the lower main conduit at station 57+08. The existing Gully Brook pressure conduit was designed to discharge 400 cfs with the Connecticut River at a stage of 34.5 feet msl. Contribution from this tributary is not included in the peak discharge of the main Park River conduit since both peaks are desynchronized by several hours, with Gully Brook having receded prior to peak flows in the Park River. The principal reason for this condition is the lagging effect produced by the South Branch headwater pool. During the

project design flood, peak outflow from this pool occurs approximately 6 hours after peak inflow. This is in consonance with the criteria used in the design of the original Park River conduit in 1940.

c. Auxiliary conduit. The 22-foot diameter auxiliary conduit is required under the adopted design conditions to discharge that portion of the peak flow in excess of 18,400 cfs and to prevent upstream ponding levels on the North and South Branches from exceeding 52 feet msl. Under design conditions, the auxiliary conduit will discharge 5,400 cfs.

d. North Branch conduit. The project design flood inflow to storage upstream of the conduit entrance (D.A. = 27.1 square miles) is 10,800 cfs. Under the design conditions with a headwater at 52⁺ feet msl, the conduit will discharge 5,400 cfs.

e. South Branch conduit. The project design flood inflow to storage is 21,600 cfs. Under the design conditions with a headwater at 52⁺ feet msl, the conduit will discharge 18,400 cfs.

6. PROPOSED CONDUIT EXTENSIONS

a. Description. The proposed conduit extensions are shown on plate 3-2 and consist of the upper main conduit on the Park River (sections 2 and 4), the North Branch conduit on the North Branch Park River (sections 7 and 9), and the South Branch conduit on the South Branch Park River (section 5). More detailed descriptions of these conduit extensions follow:

(1) Upper main conduit

(a) Section 2. This section of the conduit extension, shown on plate 3-3, is a fill-in between existing sections 1 and 3 and is 1,232 feet long. The conduit will consist of twin barrels each 34'-0" wide x 26'-6" high. The invert slopes at 0.0005 ft/ft between elevations 13.84 and 13.22 feet msl at its upstream and downstream ends, respectively.

(b) Section 4. This section, shown on plate 3-3, will extend from existing section 3 upstream to the proposed junction structure, a distance of 1,323 feet. The conduit will consist of twin barrels, each 34'-0" wide x 26'-6" high. The invert slopes

at 0.0005 ft/ft between elevations 15.37 and 14.70 feet msl at its upstream and downstream ends, respectively.

(2) North Branch conduit

(a) Section 7. This conduit extension, shown on plate 3-4, will extend from the proposed junction structure upstream to existing section 8, a distance of 1,065 feet. The proposed conduit consists of twin barrels, each 22'-0" wide x 25'-0" high. The invert slopes at 0.00246 ft/ft between elevations 18.39 and 15.77 feet msl at its upstream and downstream ends, respectively.

(b) Section 9. Section 9, shown on plate 3-4, will be 289 feet long and will extend from existing section 8 upstream to a headwall about 100 feet upstream from Farmington Avenue. The conduit will consist of twin barrels, each 22'-0" wide x 25'-0" high. The invert slopes at 0.0006 ft/ft from elevation 20.05 feet msl at its downstream end to elevation 20.22 feet msl upstream at station 42+65.

(c) Channel improvement. Work in the channel upstream of section 9 will consist of removing about 100 feet of riverbank and constructing concrete retaining walls from the conduit entrance upstream to high ground. A plan of the work is shown on plate 3-5.

(d) Entrance weir. The existing riverbed is about 6 feet above the invert at the entrance to section 9. In order to provide a smooth flow transition and to prevent erosion of the streambed, it is proposed to construct a low ogee weir having a curved crest length of 76 feet located 31 feet upstream on centerline from the conduit entrance. Elevations at the crest and toe of the weir are 27.2 and 20.22 feet msl, respectively. Plan and profile views of the weir are shown on plate 3-5.

(3) South Branch conduit. Construction of section 5, which extends 125 feet from the proposed junction structure upstream to existing section 6, will complete the enclosure of the South Branch Park River. The conduit, shown on plate 3-3, will consist of twin barrels, each 36'-0" wide x 27'-6" high. The invert will slope at 0.0008 ft/ft from the junction structure at elevation 15.75 feet msl to the end of section 6 at elevation 15.85 feet msl.

b. Hydraulic analysis

(1) General. The hydraulic analysis of the Park River local protection project is complicated due to the fact that open channel flow, pressure flow and headwater pool storage will all occur in the periods preceding and subsequent to the desynchronized peak discharges of the North and South Branch project design flood hydrographs. (These conditions can also occur as the Connecticut River rises and approaches the design flood stage). However, pressure flow will occur throughout the entire conduit system during the project design flood inflow with the coincident Connecticut River at the design stage of 30 feet msl. Hydraulic design criteria and assumptions employed in the analysis are presented in the following paragraphs.

(2) Head loss coefficients

(a) Friction losses. Theoretical values of Manning "n" were calculated for all typical sections of the conduit system utilizing the Darcy-Weisbach resistance coefficient "f" and the relationship, $f = 185n^2/D^{1/3}$. Values of "f" were taken from plate 8 of EM 1110-2-1602. The basic assumptions used in calculating the relative roughness and the Reynolds number were as follows:

Absolute roughness (ϵ) = 0.001 for portions of the system constructed since 1965.

Absolute roughness (ϵ) = 0.002 for conduits constructed during the 1940's.

Kinematic viscosity $\nu = 12.17 \times 10^{-6}$ (Temperature = 60° Fahrenheit). The Reynolds number varied from 2.18×10^7 to 2.77×10^7 and Manning "n" varied from 0.0124 to 0.0133. For determination of pressure and energy gradelines a value of "n" = 0.013 was adopted.

(b) Other head loss coefficients. Bend loss coefficients, taken from the suggested design curve on plate 7 of EM 1110-2-1602, are listed in table 1.

Entrance loss coefficients for the North and South Branches were assumed to be 0.3. Exit loss coefficients at the

TABLE 1

BEND LOSS COEFFICIENTSLower Main Conduit

<u>Station</u>	<u>Coefficient (Kb)</u>
11+20	0.01
16+50	0.04
21+00	0.04
27+00	0.01
31+00	0.02
37+10	0.01
39+40	0.03
44+30	0.02
59+90	<u>0.09</u>
Total	0.27

Upper Main Conduit

10+00	0.09
16+00	0.04
23+50	0.06
28+50	0.05
32+50	0.02
39+00	0.02
42+00	0.02
49+50	<u>0.08</u>
Total	0.38

North Branch Conduit

3+00	0.05
6+50	0.01
10+50	0.02
15+00	0.01
21+50	0.02
31+00	<u>0.05</u>
Total	0.16

South Branch Conduit

58+00	0.05
64+00	<u>0.10</u>
Total	0.15

lower main and auxiliary conduits were assumed to be 1.0. The transition loss coefficient (contraction coefficient) for the lower main conduit was assumed to be 0.2.

Losses through the junction structure were computed using data obtained from a physical model study conducted at the Alden Research Laboratories of the Worcester Polytechnic Institute, Holden, Massachusetts. Values of the loss coefficients are shown in table 2 and explained in paragraph 7. The model study report is an appendix to this memorandum.

(3) Open channel flow analysis. An analysis was made to determine over what range of discharges open channel flow conditions would exist in the various components of the conduit system. Water surface profiles were determined for the main and branch conduits using HEC computer program 723-X6-L202A, dated October 1973.

(a) Low tailwater condition. With the Connecticut River at or below 4 feet msl, hydraulic and energy gradelines were determined for flows varying from 1,000 to 23,150 cfs in the main conduit. In the reach of the lower main conduit between stations 7+34 and 37+21 subcritical flow occurs for discharges up to 14,000 cfs; pressure flow conditions exist beyond this value. Supercritical flow occurs for discharges up to 20,000 cfs in the reach between stations 37+21 and 54+48 with pressure flow conditions existing for discharges greater than 20,000 cfs. Under the open channel flow conditions, Froude numbers range from 1.0 to 1.6 indicating that undular type hydraulic jumps will occur in this reach.

In the upper main conduit, which extends from station 58+48 upstream to the junction structure, flows are in the subcritical state. The discharge capacity is controlled at the transition between the upper and lower main conduit sections for flows up to the 20,000 cfs value.

To establish conditions for hydraulic and energy grade-line analysis in the North and South Branch conduits (for the case of low Connecticut River tailwater), synchronized values of inflow were taken from the project design flood hydrographs presented in Design Memorandum No. 1 - Hydrology and used in the backwater computations. Subcritical flow occurs in both conduits.

At the entrance to the North Branch conduit, supercritical flow occurs below the weir for discharges less than 4,600 cfs. Values of the Froude number are less than 2.5; therefore, surface turbulence rather than a strong hydraulic jump occurs. For discharges greater than 4,600 cfs, backwater from the North Branch conduit creates submergence conditions on the weir and subcritical flow prevails.

(b) Design tailwater condition. With the Connecticut River at the design stage of 30 feet msl, pressure flow will occur in the lower main conduit for the entire range of discharges. Open channel flow will occur in the upper main conduit and the North and South Branch conduits for discharges up to 14,000 cfs in the main conduit.

(4) Pressure flow analysis. Analysis was made of the flow characteristics of the conduit system for the design case involving project design flood inflows to the North and South Branch conduits with coincident Connecticut River tailwater stage at 30 feet msl. Project design flood inflows were reported previously in Design Memorandum No. 1 - Hydrology and were determined by routing inflow hydrographs through headwater pool storage while limiting the lower main conduit capacity to approximately 18,000 cfs and headwater pool levels on the North and South Branches of the Park River to elevation 52⁺ feet msl. Excess flows were discharged through the auxiliary conduit.

In this hydraulic analysis, refinement was made to the routing procedures using more precise computations of conduit system headloss attributable, in part, to data from the completed hydraulic model study of the junction structure. Because the stage-discharge relationship at each branch conduit is affected by coincident flows contributed to the junction structure by the other, a trial and error procedure was employed. Each trial involved the computation of system headlosses using outflows from headwater storage at both branch conduits and then adding these losses to the design tailwater elevation to determine pool stages at each conduit entrance. The trials were completed when the pool elevations thus determined equalled the pool elevations resulting from the inflow routing process. Headwater pool area-capacity versus depth curves used in these computations are presented on plate 3-15.

Final design pool elevations for the North and South Branches are 51.5 and 52.3 feet msl, respectively. The resulting peak design discharges are as follows:

Upper and lower main conduits	18,400 cfs
Auxiliary conduit	5,400 "
South Branch conduit	18,400 "
North Branch conduit	5,400 "

Hydraulic and energy gradelines for the entire conduit system under these design discharge conditions are shown on plate 3-14.

(5) Hydraulic elements. Curves providing hydraulic element data for the North and South Branch conduits and the upper and lower main conduits are shown on plates 3-7 through 3-10. Included on the plates are curves of normal and critical discharge, area, and hydraulic radius, all versus depth, per barrel. Discharges are based on a Manning "n" of 0.013.

(6) Discharge rating curves. For use in post flood analyses, discharge rating curves have been developed for each component of the conduit system. Plate 3-11 provides a series of curves giving the relationships between headwater pool elevations at the North and South Branch conduits versus discharge for a range of energy gradient elevations measured at the junction structure. Another series of curves on plate 3-12 provides the relationships between energy gradient elevation measured at the junction structure and discharges in the main (upper and lower) and auxiliary conduits for a range of Connecticut River tailwater levels.

The curves on plate 3-13 that relate hydraulic gradeline in feet above mean sea level to discharge for a range of Connecticut River tailwater levels apply specifically to station 39+00 in the upper main conduit where installation of a liquid level measuring device is proposed. This device will be housed in the pumping station at that location and, in conjunction with measurements of the Connecticut River stage obtained from an existing NED radio gage located at the Bulkeley Memorial Bridge one-half mile upstream from the confluence of the Park River, will be used to determine discharges in the main conduit.

(7) Velocities

(a) Main conduit. Maximum velocities will occur with a discharge of 20,000 cfs and the coincident Connecticut River stage at 4 feet msl. In sections 2 and 4, maximum velocities are 14.2 and 13.6 fps, respectively. Velocities decrease for flows above 20,000 cfs due to pressure flow in the lower main conduit and the resultant backwater effect on the upper main conduit. Under design conditions, with a discharge of 18,400 cfs, the velocity is 10.5 fps.

(b) North Branch. In sections 7 and 9, the maximum velocities are 10.8 and 10.6 fps, respectively. These velocities will occur with the Connecticut River at or below 4 feet msl. At the entrance weir, a maximum velocity of 11.1 fps will occur at a flow of 2,400 cfs with the low tailwater condition. Under design conditions, with a discharge of 5,400 cfs, the velocity is 5.0 fps.

(c) South Branch. In section 5, a maximum velocity of 11 fps will occur with a design inflow and the low Connecticut River stage. Under design conditions, with a discharge of 18,400 cfs, the velocity is 9.6 fps.

(8) Air requirements

(a) Lower main conduit. As discussed in paragraph 6b(3), analysis indicates that an undular type hydraulic jump will occur between stations 37+21 and 58+48 in the lower main conduit. Consideration has been given to air requirements and possible surgence problems associated with the jump.

Within the range of discharges and tailwater levels under which the jump occurs, flows entering the jump possess Froude numbers less than 1.6. Review of technical literature leads to the conclusion that, for this range of Froude numbers, air demand is very small and can adequately be supplied by air available in the conduits above this reach. Specific reference is made to a paper by A. A. Kalinske and James M. Robertson entitled, "Entrainment of Air in Flowing Water: Closed Conduit Flow." The paper was published in the "Transactions, ASCE," Volume 108, dated 1943.

(b) South Branch conduit. An air vent will be located

in the South Branch conduit just upstream from the junction structure. The need for the air vent was determined by study of flow conditions in the physical model of the junction structure (see Appendix). Under high discharges with pressure flow in the upper main conduit, air was drawn down the South Branch conduit. A pulsating effect took place as the air collected in the junction structure and then surged back upstream. An air vent was then installed in the model to discharge the air pocket and smooth flow conditions were achieved. The location and dimensions of the prototype air vent are shown on plate 3-17.

7. PROPOSED JUNCTION STRUCTURE

a. Purpose and location. The purpose of the junction structure is to combine inflows from the North and South Branch twin-barrel conduits and discharge flows into the twin-barrelled upper main conduit and the 22-foot diameter auxiliary conduit.

The structure is located at the present confluence of the North and South Branches of the Park River as shown on plate 3-3.

b. Geometry. The length, width and invert elevation of the junction structure were fixed by the alignment and geometry of the existing conduit sections. Other geometric considerations such as the location of roof support beams, location and orientation of supporting piers, and the optimum location and shape of the entrance to the auxiliary conduit were determined by hydraulic model study.

c. Hydraulic model study. A hydraulic model study of the junction structure was completed in July 1974 by the Alden Research Laboratories of the Worcester Polytechnic Institute. The objective of the study was to determine the distribution and characteristics of flow through the junction structure and in the entrance to the auxiliary conduit. The model was built using a linear geometric scale ratio between model and prototype of 1:25 with hydraulic characteristics based on equality of Froude numbers for model and prototype. A model study report is included in the Appendix to this memorandum. Study results are briefly summarized as follows:

(1) Piers and other geometric configurations, as shown on figure 3 of the appended report, produced satisfactory flow conditions.

(2) Adopted auxiliary conduit inlet geometry produced smooth flow conditions with minimum headloss.

(3) The junction structure and the auxiliary conduit dropdown structure and transition operated effectively over the range of test conditions.

(4) Air requirements exist in the junction structure but are inconclusive as to need in the auxiliary conduit dropdown structure.

Hydraulic gradients for several open channel and pressure flow conditions are included at the end of the model study report. Using these data, headloss coefficients were derived by assuming that the headloss for flows entering the junction structure from the North and South Branch conduits will be twice the loss occurring at the entrance to the auxiliary and main conduits. These coefficients were used to compute headlosses in the prototype and are summarized in table 2.

TABLE 2

JUNCTION STRUCTURE
HEADLOSS COEFFICIENTS

<u>Location</u>	<u>Pressure Flow</u>	<u>Open Channel Flow</u>
Upper main conduit entrance	0.16	0.07
Auxiliary conduit entrance	0.50	Weir Control
South Branch conduit exit	0.33	0.17
North Branch conduit exit	0.58	0.33

d. Junction structure modifications. After completion of the model study, modifications were made to the geometry of certain elements as the result of revised structural design criteria. Additional roof supports were needed and the changes are as follows:

(1) A 4-foot wide beam will span the junction structure from the midpoint of the North Branch conduit to the midpoint of the upper main conduit north barrel. The beam will project into the flow by 0.31 foot at the North Branch and 1.46 feet at the main conduit.

(2) All beams and piers will be 4 feet wide. Rounded piers will be constructed at all dividing walls as shown on plate 3-16.

(3) The cantilevered beam tested in the model configuration will be extended to the midpoint of the upper main conduit south barrel.

After discussion with engineers at the Alden Laboratories it was concluded that the modifications would have little or no effect on flow conditions and headlosses in the junction structure and that further testing would not be required. A plan of the modified junction structure is provided on plate 3-16.

8. PROPOSED AUXILIARY CONDUIT

a. Geometry

(1) General description. The 8,900-foot long conduit extends from the junction structure to the Connecticut River as shown on plate 3-2. Except for a 138-foot long section where it exits from the junction structure, the conduit will be circular with a diameter of 22 feet and an invert at 14 feet below mean sea level. Contained within the 138-foot section is the entrance curve, a box-shaped dropdown structure (or spillway) and a transition from the box to circular section. A plan of the entrance section is shown on plate 3-16.

(2) Intake geometry. An elliptical curve will be located on the right side (looking downstream) of the junction structure at the auxiliary conduit entrance to improve flow conditions. The shape of the curve was determined at the Alden Research Laboratories and tested in the hydraulic model. The curve has the following equation:

$$\left(\frac{x}{50}\right)^2 + \left(\frac{y}{25}\right)^2 = 1$$

A 3-foot high sill will be constructed at the entrance to prevent flows less than the rate of 1,000 cfs from discharging into the auxiliary conduit. The purpose of this is to mitigate against the continual introduction of sediments into the low level auxiliary conduit during normal flow periods. The upstream face of the sill will be rounded with a 1.5-foot radius. The sill slopes in elevation

from 18.74 feet msl at its upstream end to elevation 16.40 feet msl at the origin of the dropdown structure 35 feet downstream.

(3) Dropdown structure. A 22'-0" square box conduit section with curved invert will convey the flow from the intake to the low level auxiliary conduit. The curvature of the invert is that of an ogee-shaped overflow spillway with a tangent between crest and toe curves. The crest curve is based on the following equation with the design head, $H_d = 20$ feet:

$$x^{1.85} = 2.0 H_d^{0.85} y$$

The curve carries the invert from elevation 16.40 down to 1.29 feet msl over a horizontal distance of 25 feet. The toe curve has a radius of 32'-0" and terminates at the horizontal invert of the auxiliary conduit at elevation -14.0 feet msl. The overall length of the dropdown structure is 52.9 feet. Details of the dropdown structure are shown on plate 3-17.

(4) Transition. The 22'-0" square box-shaped section continues approximately 22 feet downstream from the end of the dropdown structure. Over the next 25 feet the cross section transitions uniformly to the 22'-0" circular auxiliary conduit. Plots of the fillet radius and area versus distance along the transition are provided on plate 3-17. Flow conditions in the transition were investigated and observed during the hydraulic model study and found to be satisfactory for all test cases.

(5) Air vent. The physical model tested at the Alden Research Laboratories included an air vent located above the dropdown structure (see figure 4 of the appendix). During the model study, flow conditions were observed with the air vent closed, partially open and fully open to the atmosphere. In each case there was no apparent air demand nor were any changes in flow conditions observed. However, due to the relative insensitivity of the model to air entrainment and because of the great length of the auxiliary conduit and its location in an urban environment, it was concluded that an air vent should be included in the prototype as a conservative measure. This will assure a means of air intake or escape to prevent the possibility of air "gulping" or "blowback".

Several flow conditions were investigated to determine the required size of vent. Maximum flow velocity occurs at a discharge

of 3,000 cfs with low Connecticut River tailwater. Under this condition the Froude number is 3.25. Using HDC chart 050-3, assuming no air is supplied by the junction structure, results in an air demand rate of 225 cfs. The normal practice of limiting the air velocity to 150 fps requires the use of an 18-inch diameter vent. However, as the vent will be located in an urban park, public safety considerations warrant using a lower design velocity. Thus, a 36-inch diameter vent will be employed which results in an air velocity of 32 fps or 22 mph.

(6) Outlet stoplog structure. Construction of a stoplog structure downstream of the existing Connecticut River floodwall has been proposed. The purpose of the structure would be to allow future inspection and maintenance of the auxiliary conduit.

Although the design is not finalized a proposed layout is shown on plate 3-19. Transition from a circular to a rectangular section at the outlet will be included in the final design. Complete details will be presented in GDM - Phase II, Part II, Auxiliary Conduit.

b. Hydraulic analysis

(1) General. At low Connecticut River stages the entrance dropdown will control discharges up to 5,000 cfs. Pressure flow with control at the outlet will exist for higher discharges and for all discharges with the Connecticut River at the design stage of 30 feet msl.

(2) Head loss coefficients

(a) Friction loss. An effective roughness value of $k_s = 0.001$ was adopted upon examination of the values for several wood form concrete conduits presented in HDC sheet 224-1. This is considered to be a conservative value as the greater likelihood exists that steel form or precast lining will be used in the construction. At design discharge the Reynolds number $R_e = 2.77 \times 10^7$ and the resistance factor "f" and the Manning "n" are 0.102 and 0.0124, respectively. For design capacity purposes, a value of "n" = 0.013 was adopted.

(b) Other headloss coefficients. Bend loss coefficients were determined using plate 7 in EM 1110-2-1602 and are listed in table 3.

TABLE 3

AUXILIARY CONDUIT
BEND LOSS COEFFICIENTS

<u>Station</u>	<u>Coefficient</u>
11+80	0.03
20+60	0.04
28+00	0.03
97+00	0.07

An entrance loss coefficient of 0.50 was assumed as discussed earlier in paragraph 7c. At the outlet a loss coefficient of 1.0 was used assuming that there would be no velocity head recovery.

The headloss coefficient for flow contraction in the transition from box to circular section at the end of the dropdown structure was computed from model study data to be 0.2 (applied to the change in velocity head across the transition).

(3) Entrance control. Under low Connecticut River tailwater conditions, flow rates up to 5,000 cfs in the auxiliary conduit are hydraulically controlled at the beginning of the dropdown structure. Weir type flow conditions exist and the energy-discharge relationship is expressed by the basic formula $Q = CLH^{3/2}$ where "H" is measured as the height of the energy gradient in the junction structure above the crest of the dropdown structure. In the initial analysis, a "C" value of 2.8 was employed which was selected from broad crest coefficients presented in "Weir Experiments, Coefficients and Formulas," Robert E. Horton, USGS WSP No. 200, 1907. This value was later verified by computations using model study data results.

For flow rates ranging from 5,000 to 7,000 cfs weir flow conditions still control but with increasing effect of submergence and corresponding decrease in the discharge coefficient.

(4) Exit control. Pressure flow conditions will exist for all discharge rates above 7,000 cfs with a low Connecticut River stage and for the entire range of discharge rates when the Connecticut River is at the design stage of 30 feet msl.

(5) Discharge rating curves. Hydraulic element curves for the auxiliary conduit are shown on plate 3-18. The curves present area, hydraulic radius and critical flow rate versus depth.

Plate 3-12 presents curves giving the relationship between auxiliary conduit discharge and the energy gradeline elevation at the junction structure for a range of Connecticut River tailwater stages.

c. Sedimentation. The auxiliary conduit will be level from the toe of the dropdown structure to the outlet and during normal Connecticut River stages will be partially filled with essentially still-water to a depth of approximately 17 feet. Because of this condition with its extended duration over the project lifetime, consideration was given to the possibility of sediments being trapped which are introduced by both the Park River at the conduit entrance and the Connecticut River at its outlet.

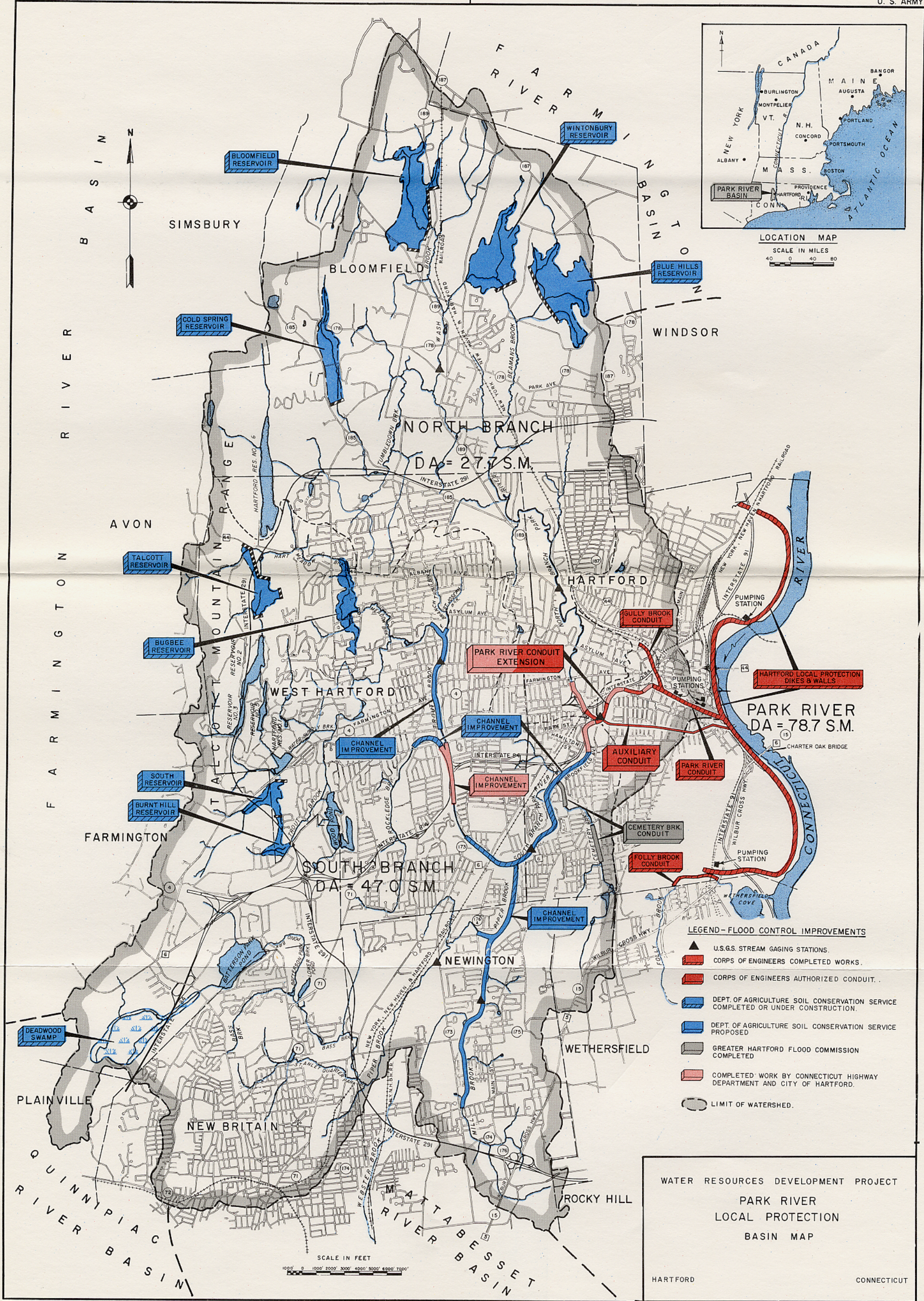
The magnitude of the sediment load has not been determined by precise measurements but by inspection of flows in the existing Park River conduit and through discussions with engineers of the Hartford office of the U.S. Geological Survey and the Metropolitan District of Hartford. It is generally accepted that the sediment load of the Park River is small which is typical of most streams in New England. The Connecticut River carries a substantially larger load but it has not been observed depositing out at the lower end (backwater reach) of the existing conduit and therefore is not considered a major contributor to the auxiliary at its outlet.

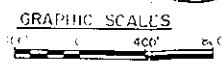
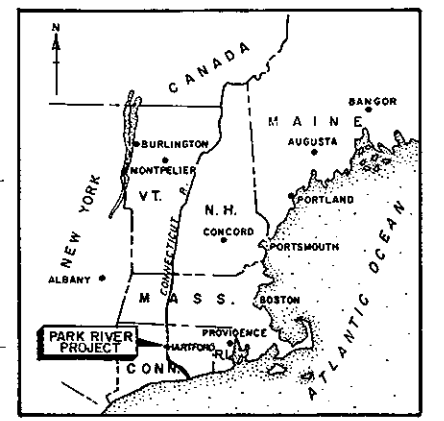
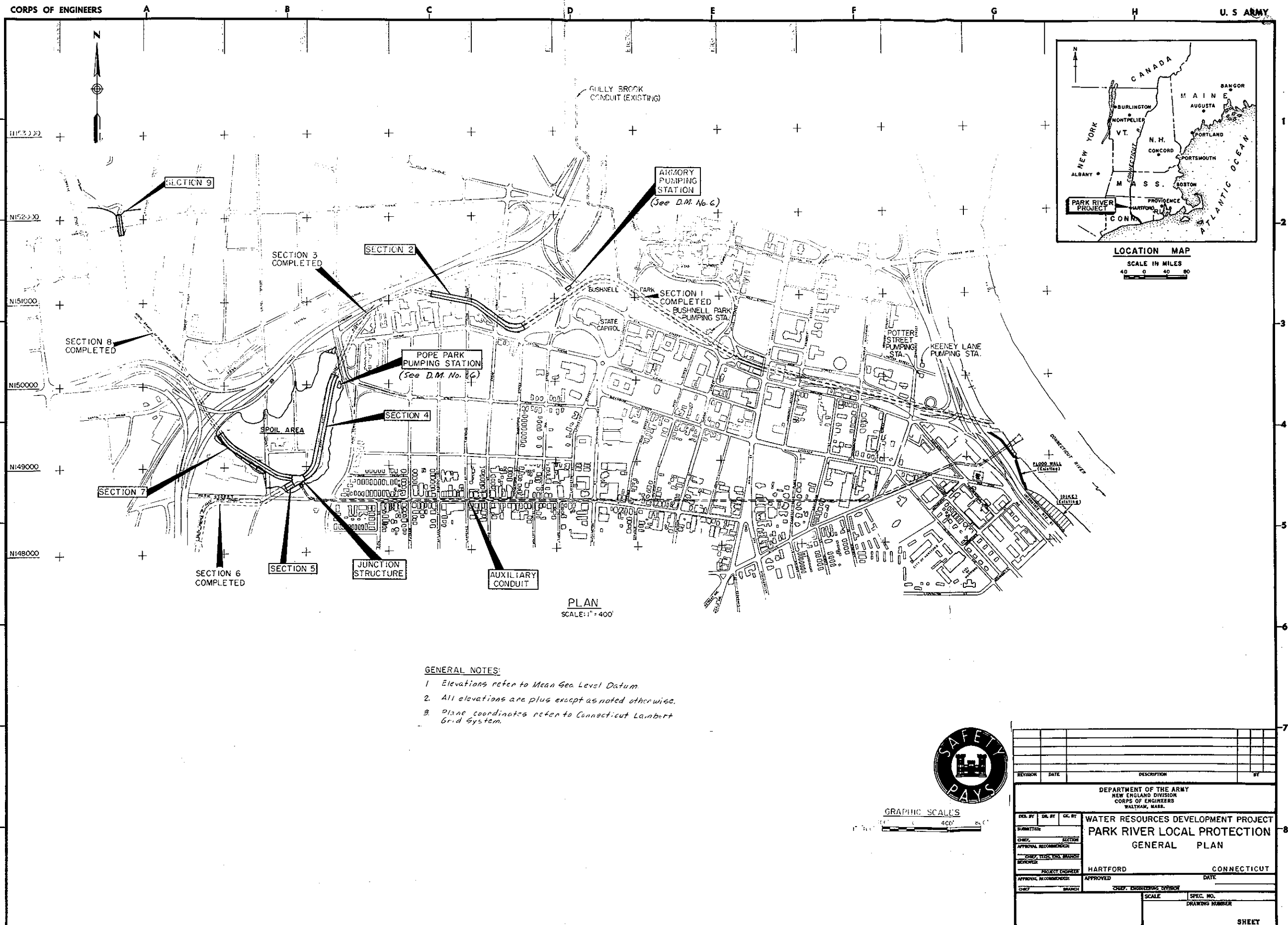
Although the Connecticut River at Hartford is subject to a 1.7 foot semidiurnal tide range, the terminus of the saline wedge extending upstream from Long Island Sound is located at Middletown, several miles downstream. This is an important observation as it is known that significant flocculation and sedimentation of suspended solids occur at the interface between fresh and saline water.

Although the magnitude of the sedimentation problem appears to be small, certain measures were taken in the design to mitigate

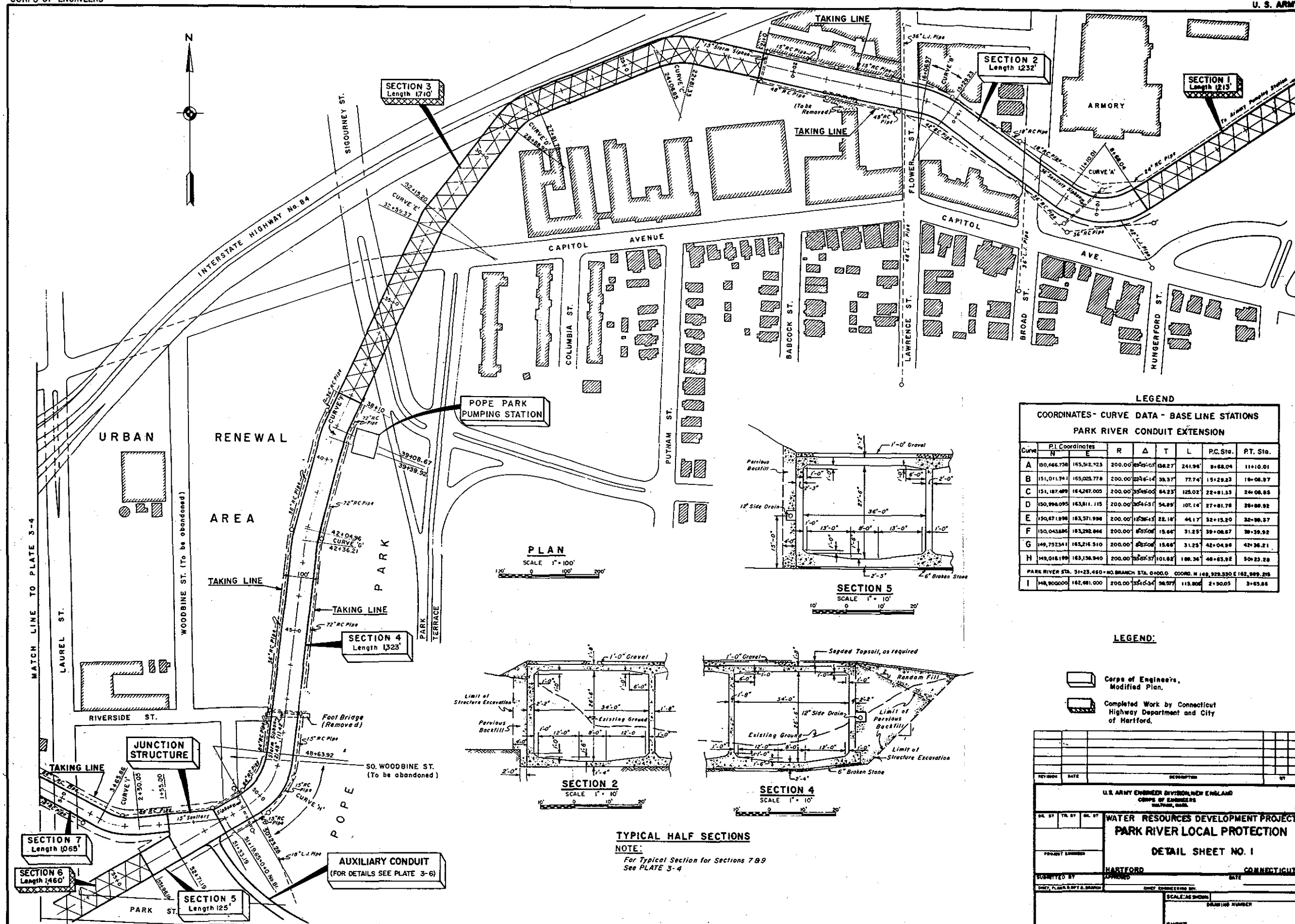
against its accumulation effects. The sill at the auxiliary conduit entrance is placed so as to prevent low and normal flows in the Park River from entering the auxiliary until discharge rates exceed approximately 1,000 cfs. For the period of streamflow record (1936-73), this rate is equalled or exceeded approximately only 3 days each year. Thus, under normal flow conditions, any suspended or bedload sediments will be carried down the continuously flowing main conduit. Also, for the more infrequent higher discharge rates, when flow enters the auxiliary conduit, most of the bedload sediment will continue to move down the main conduit.

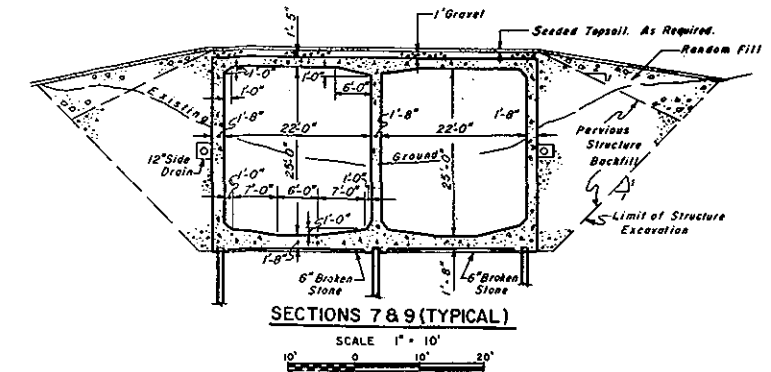
Provisions are also being made for dewatering the auxiliary and for large equipment access to allow periodic accumulated sediment cleanup operations. These are to be discussed in detail in General Design Memorandum No. 2 - Phase II, Part II, Auxiliary Conduit.





DESIGN	DATE	DESCRIPTION	BY
DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION CORPS OF ENGINEERS WALTHAM, MASS.			
DESIGNED BY	CHECKED BY	WATER RESOURCES DEVELOPMENT PROJECT PARK RIVER LOCAL PROTECTION GENERAL PLAN	
SUBMITTED	SECTION		
APPROVAL RECOMMENDED	CHIEF, STATE AND BRANCH		
REVIEWED	POLICY ENGINEER	HARTFORD	CONNECTICUT
APPROVAL RECOMMENDED	APPROVED	DATE	
CHECK	BRANCH	CHIEF, ENGINEERING DIVISION	
SCALE		SPEC. NO.	
DRAWING NUMBER		SHEET	







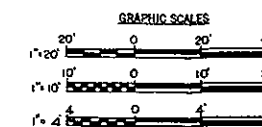
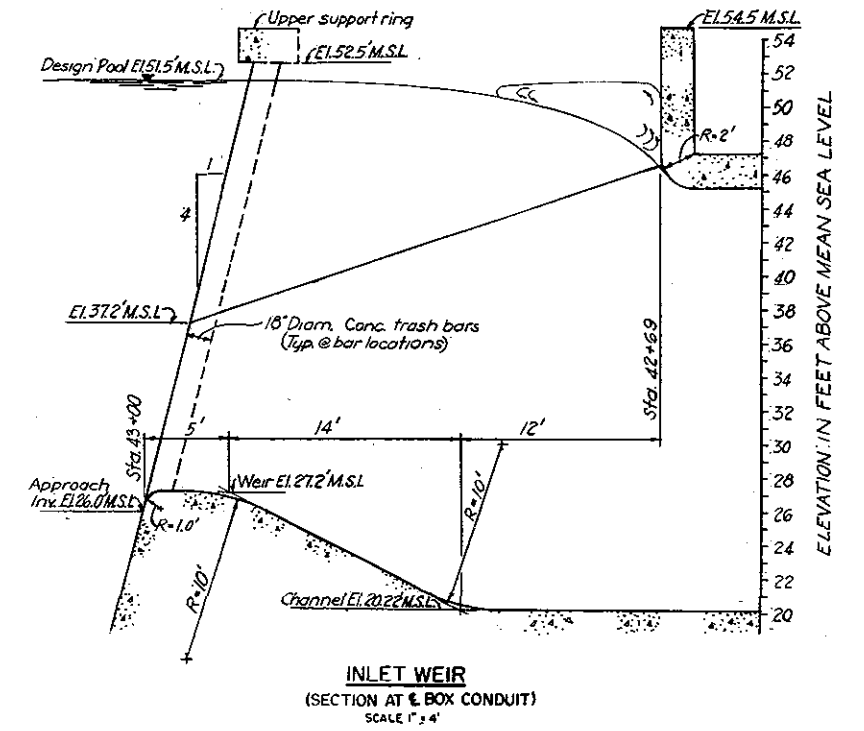
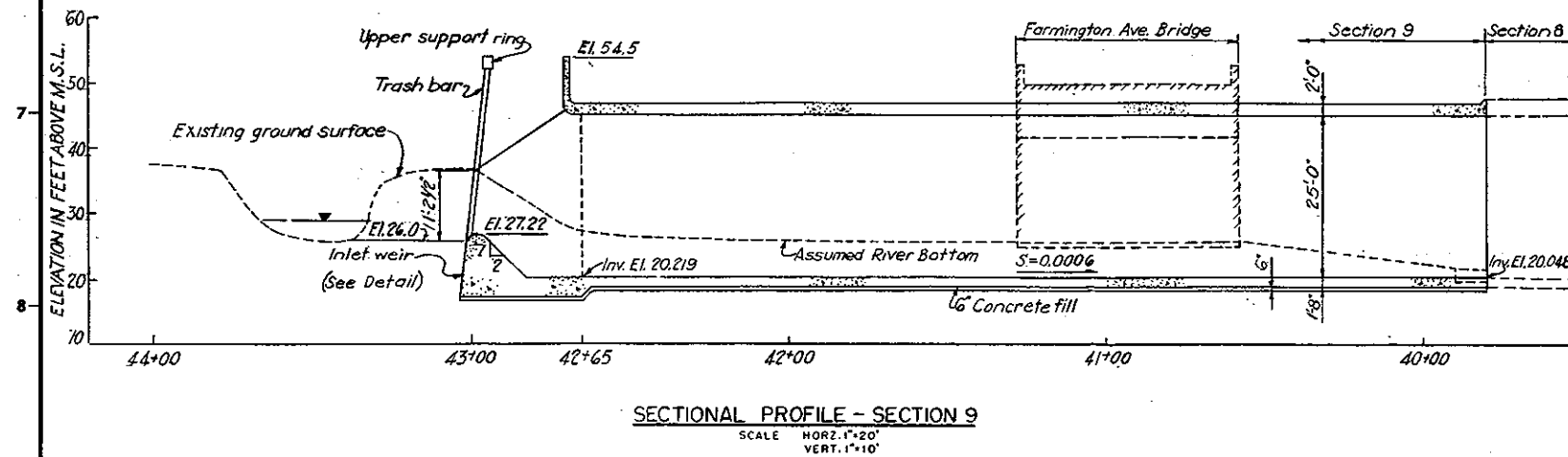
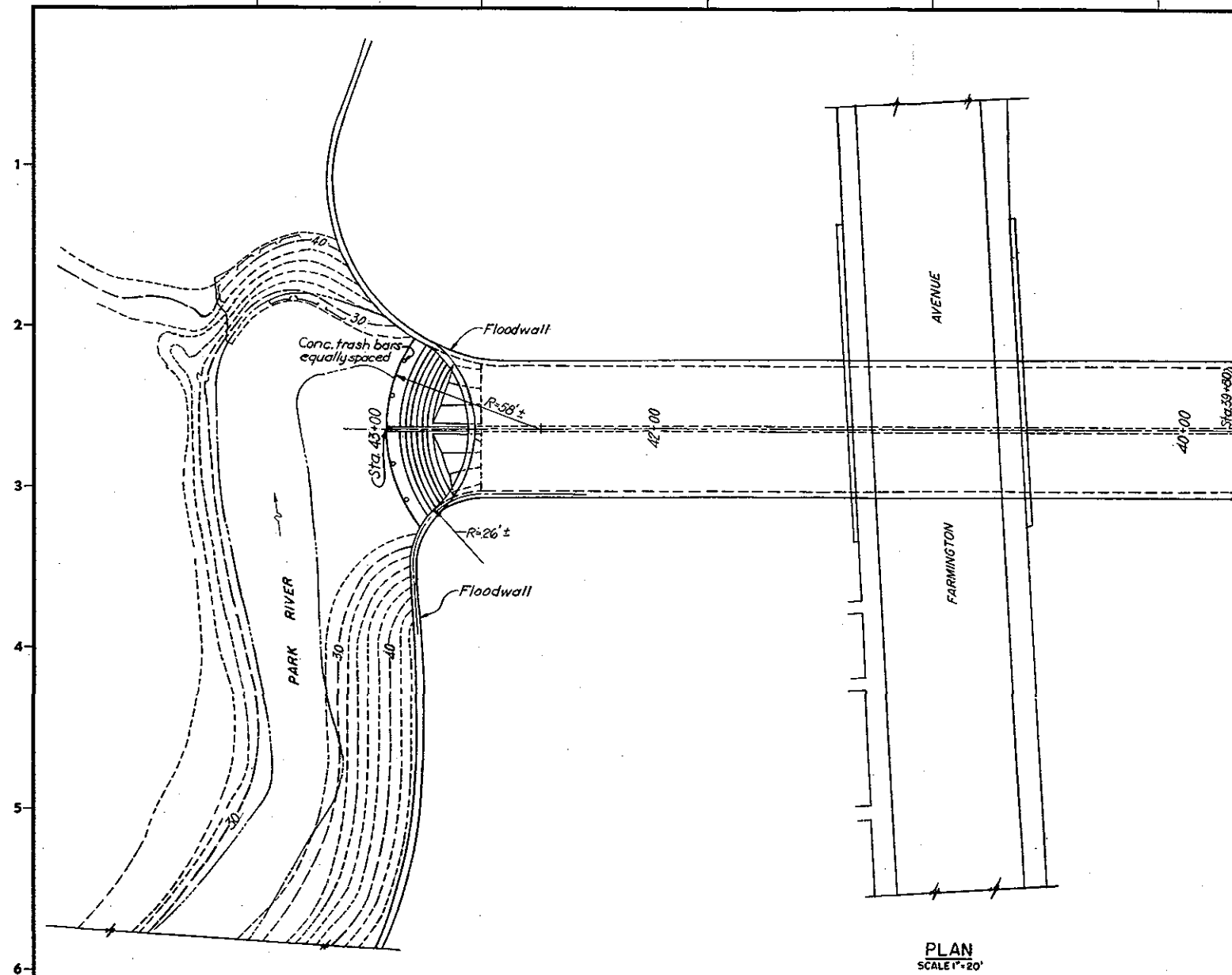
LEGEND

COORDINATES - CURVE DATA - BASE LINE STATIONS								
PARK RIVER CONDUIT EXTENSION								
Curve	P.L. Coordinates		R	Δ	T	L	P.C. Sta.	P.T. Sta.
	N	E						
J	149,037.000	162,382.000	200.00'	9°-50'-47"	16.642	33.207	6+27.350	6+60.557
K	149,297.000	162,066.000	200.00'	15°-28'-30"	27.174	54.018	10+13.548	10+67.566
L	149,671.000	161,781.000	200.00'	32°-40'-12"	17.181	34.279	14+93.424	15+27.703
M	150,249.500	161,480.000	200.00'	15°-05'-22"	26.550	52.790	21+36.095	21+88.883
N	150,930.000	160,834.000	200.00'	35°-13'-37"	63.490	122.955	30+23.482	31+46.438

LEGEND:

-  Corps of Engineers
Modified Plan
-  Completed Work by Connecticut
Highway Department and City
of Hartford.

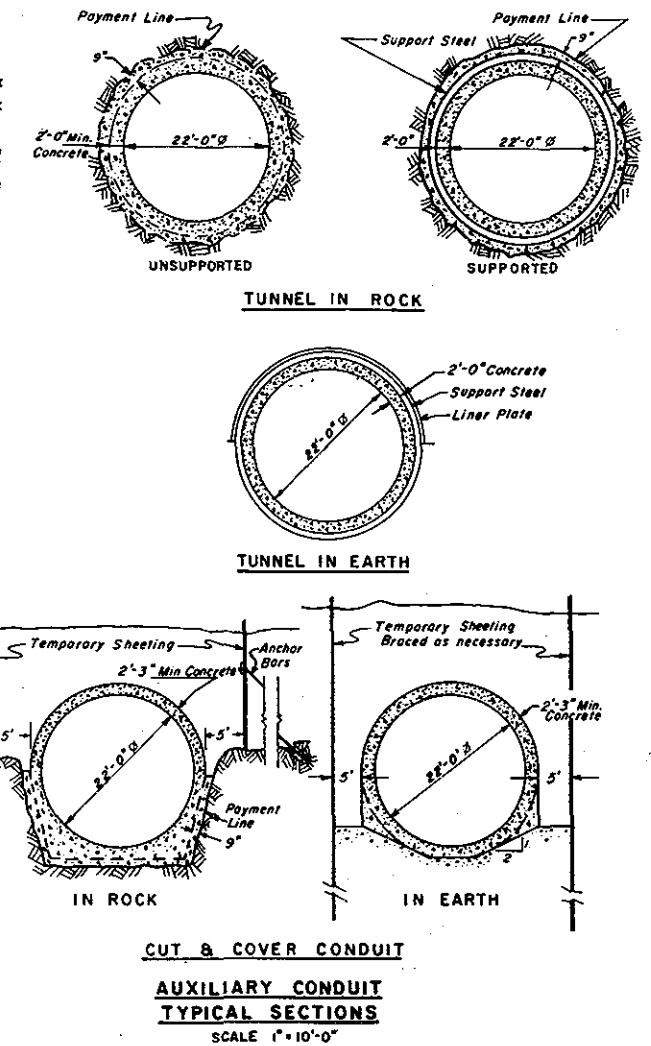
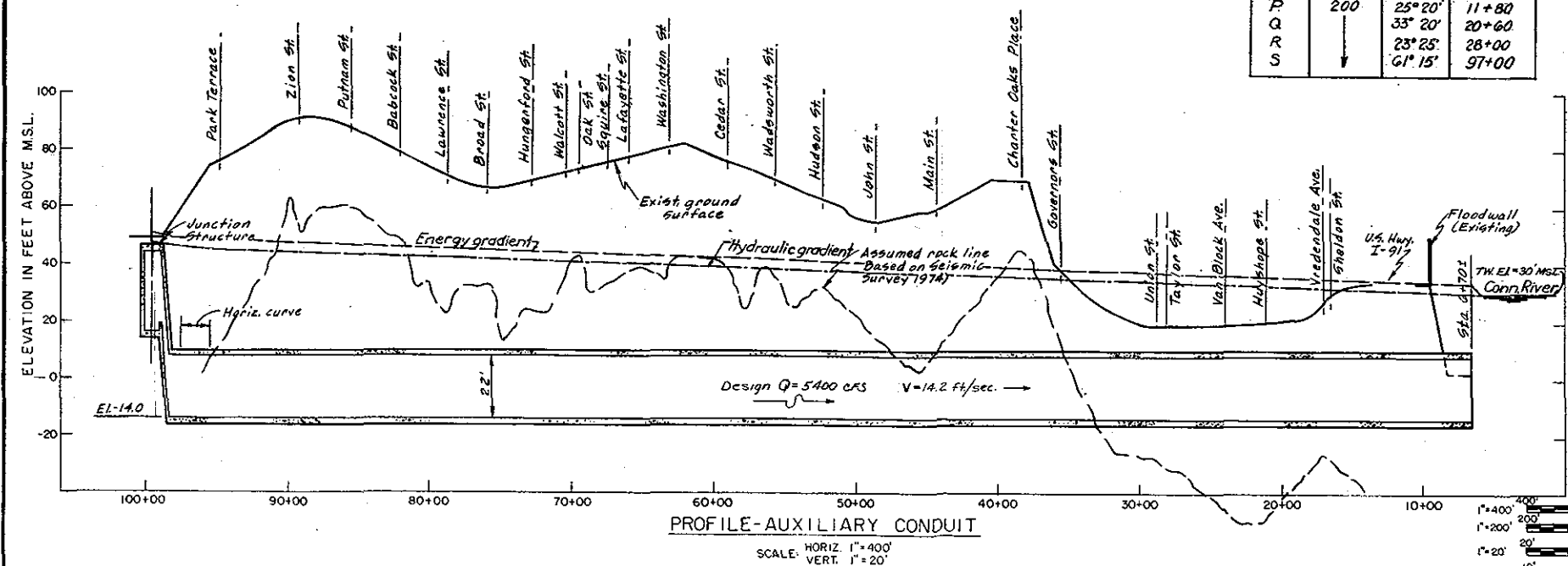
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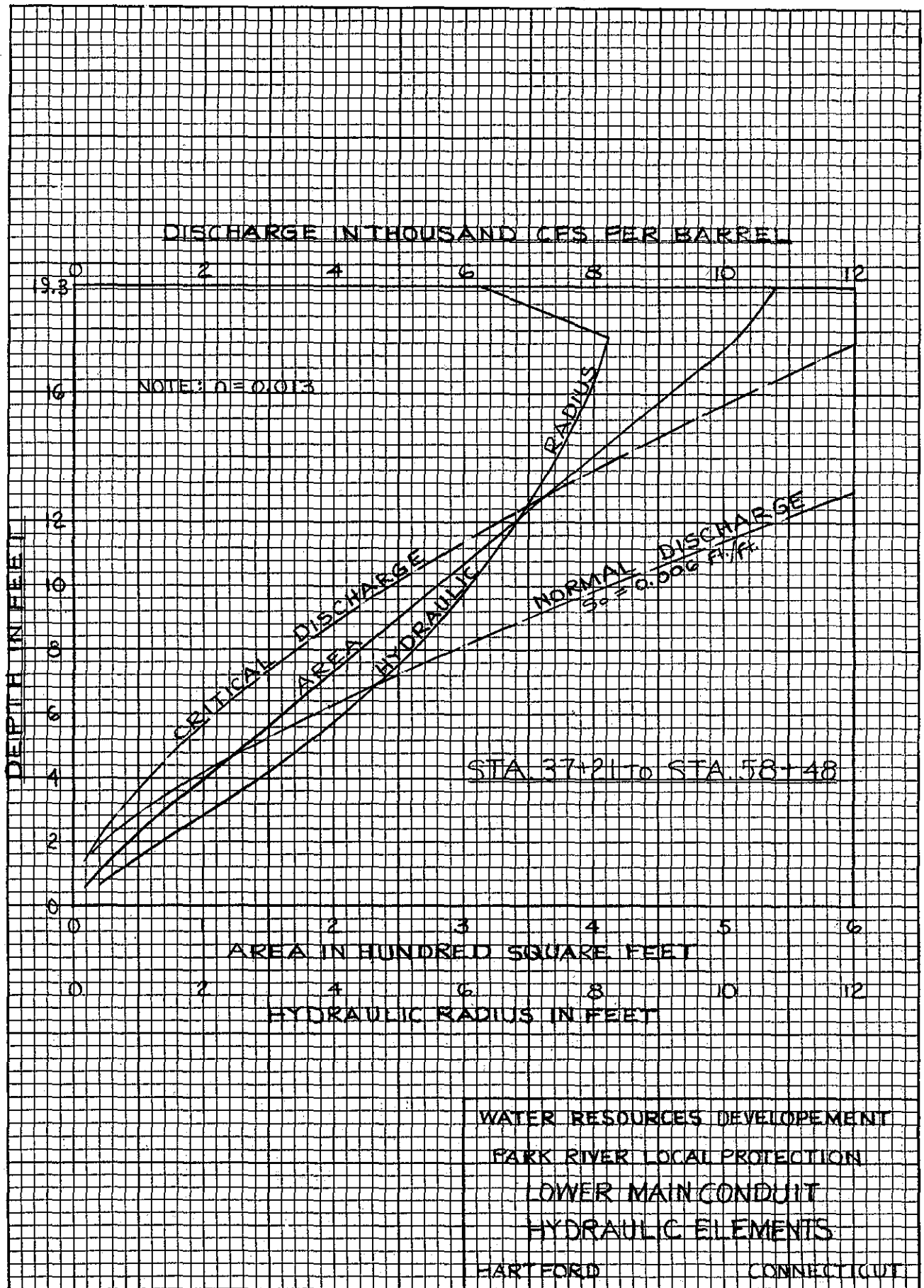


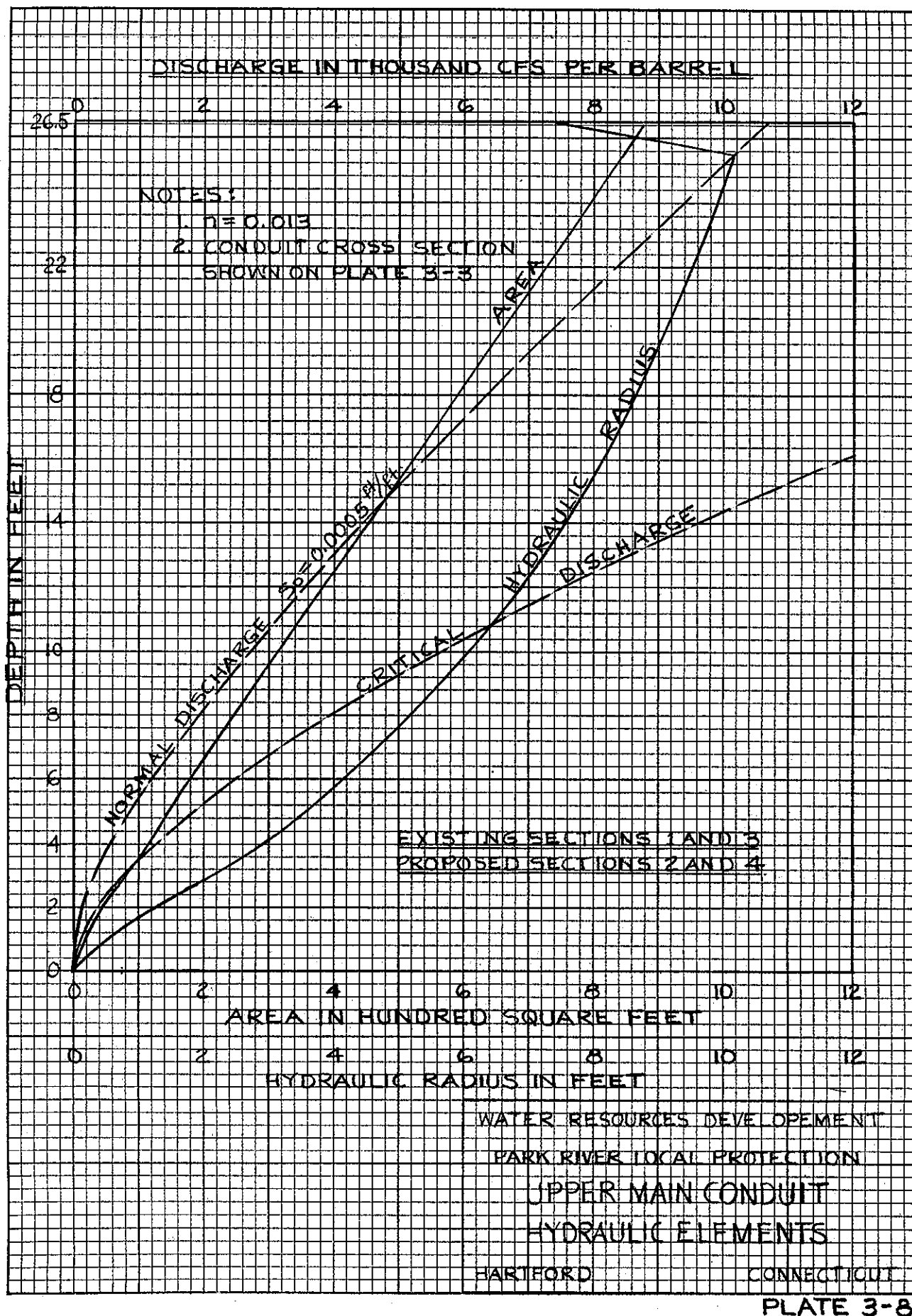
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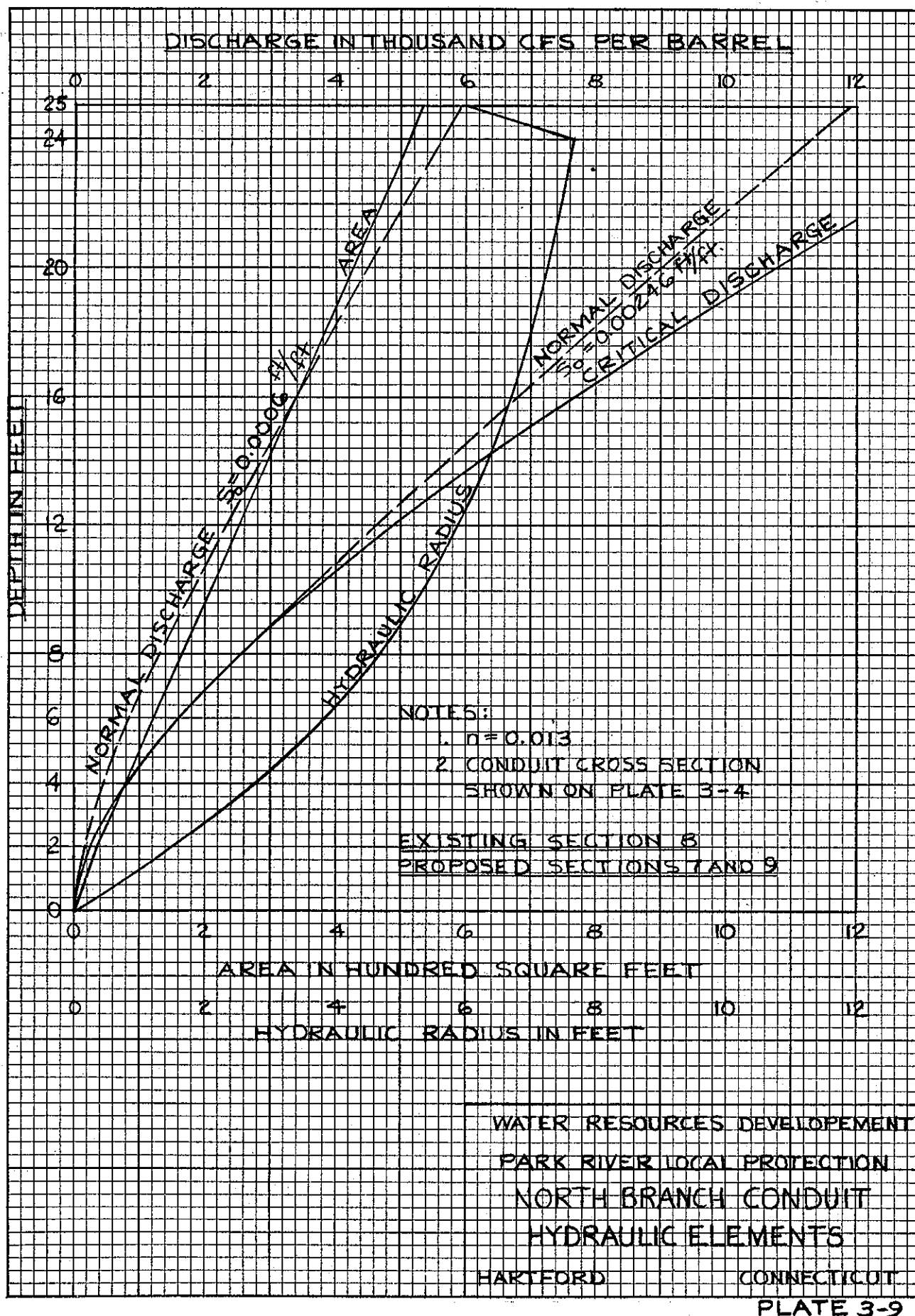
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DES. BY	CHK. BY	WATER RESOURCES DEVELOPMENT PROJECT	
SUBMITTED	SECTION	PARK RIVER LOCAL PROTECTION	
APPROVAL RECOMMENDATION		NORTH BRANCH CONDUIT-SECTION 9	
CHIEF TECH. ENCL. BRANCH		PLAN, PROFILE AND SECTION	
PROJECT ENGINEER	HARTFORD	CONNECTICUT	
APPROVAL RECOMMENDATION	APPROVED	DATE	
CHIEF	BRANCH	CHIEF, ENGINEERING DIVISION	
		SCALE	SPEC. NO.
		DRAWING NUMBER	
SHEET			

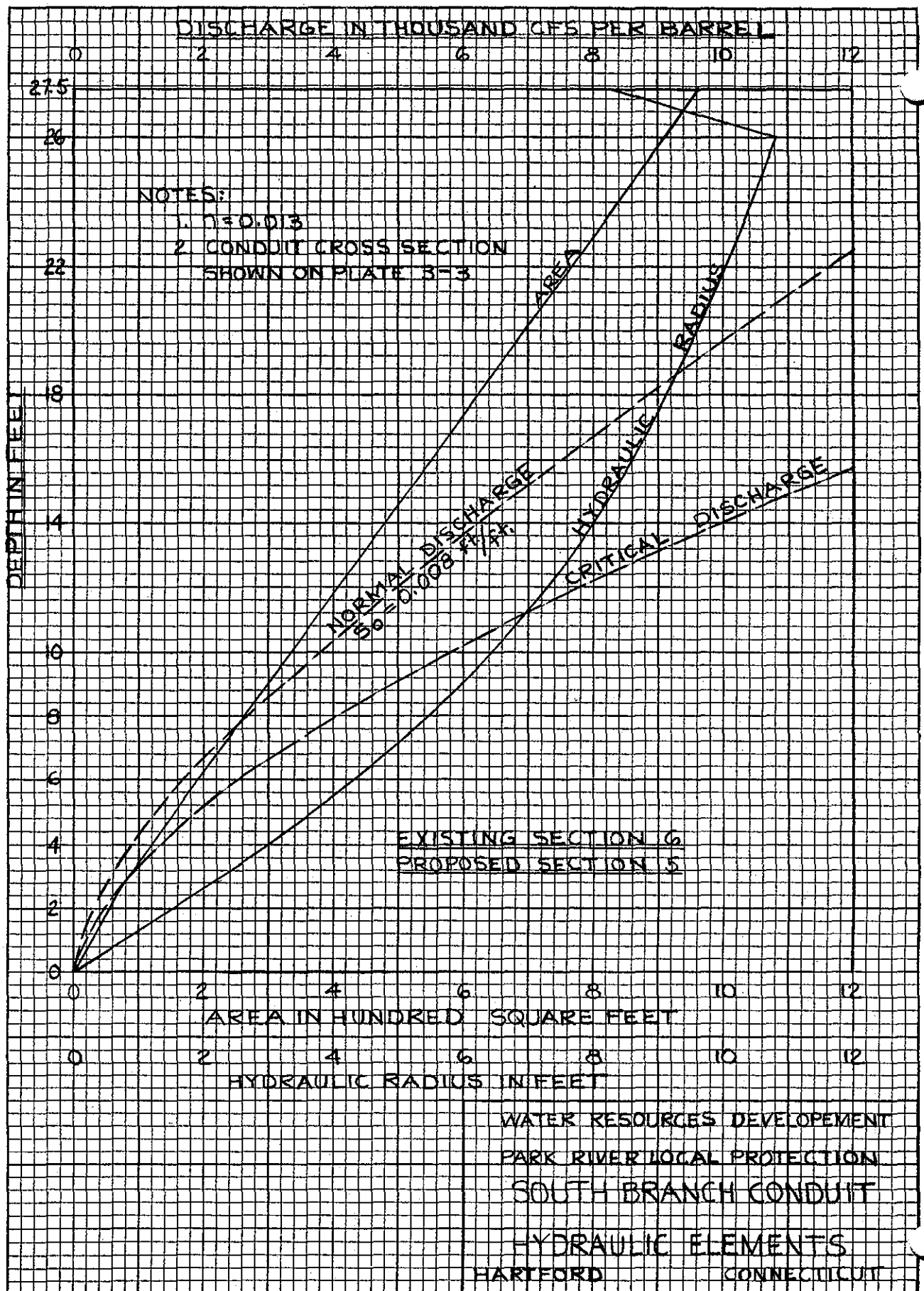
CURVE DATA			
CURVE	R (FEET)	Δ	STATION (FEET)
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Q		33° 25'	20 + 60
R		23° 25'	28 + 00
S		61° 15'	97 + 00

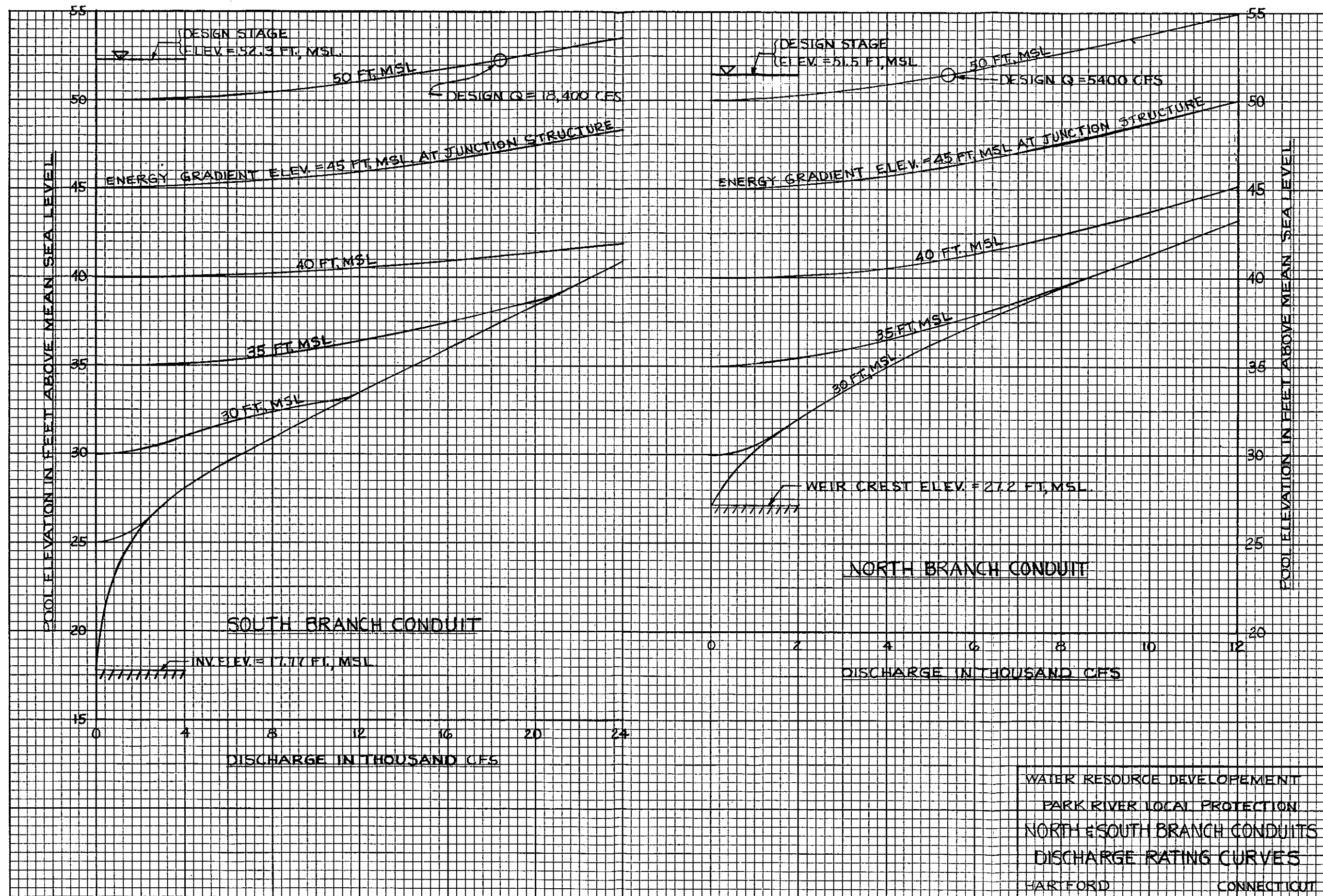
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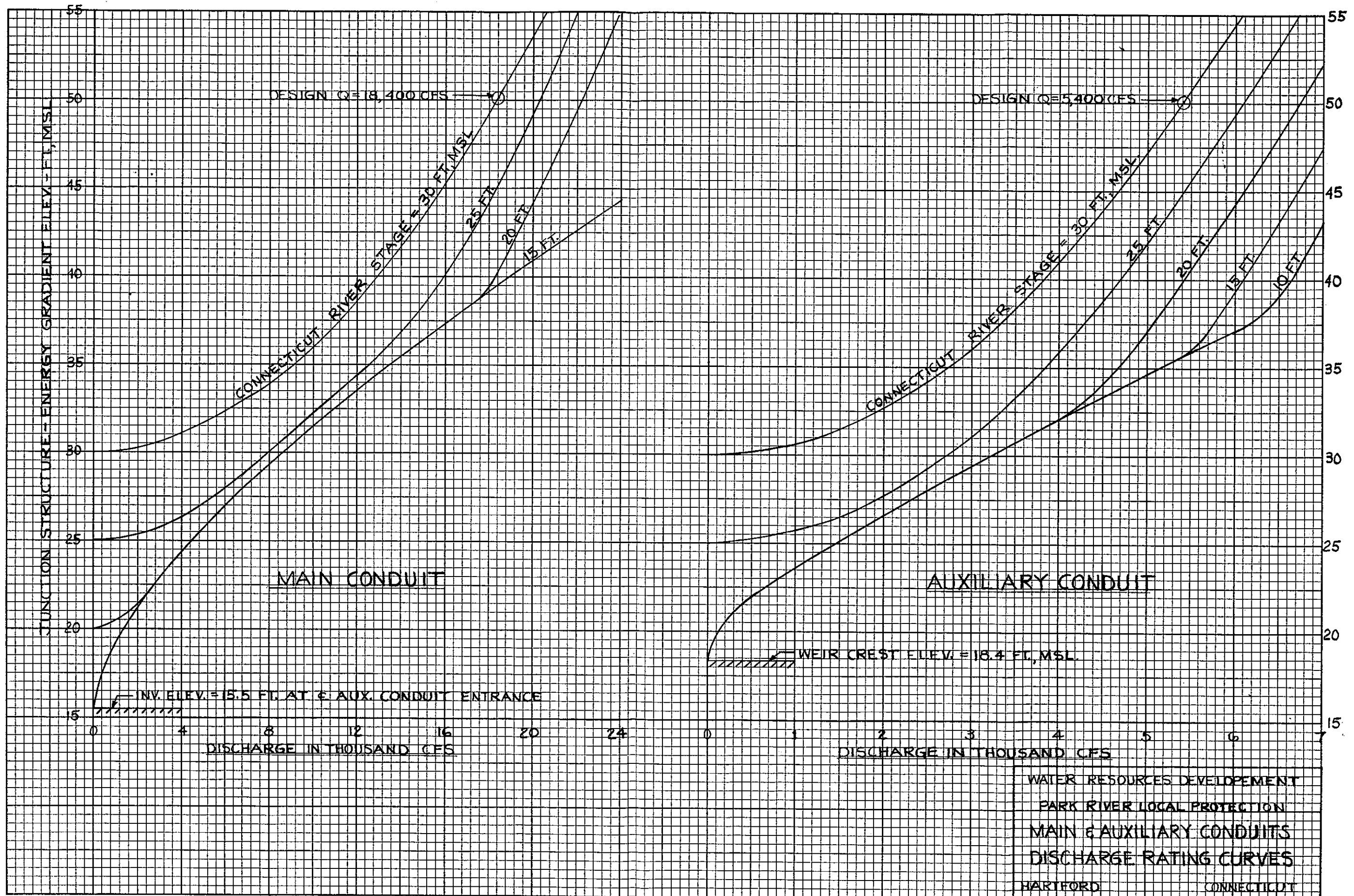


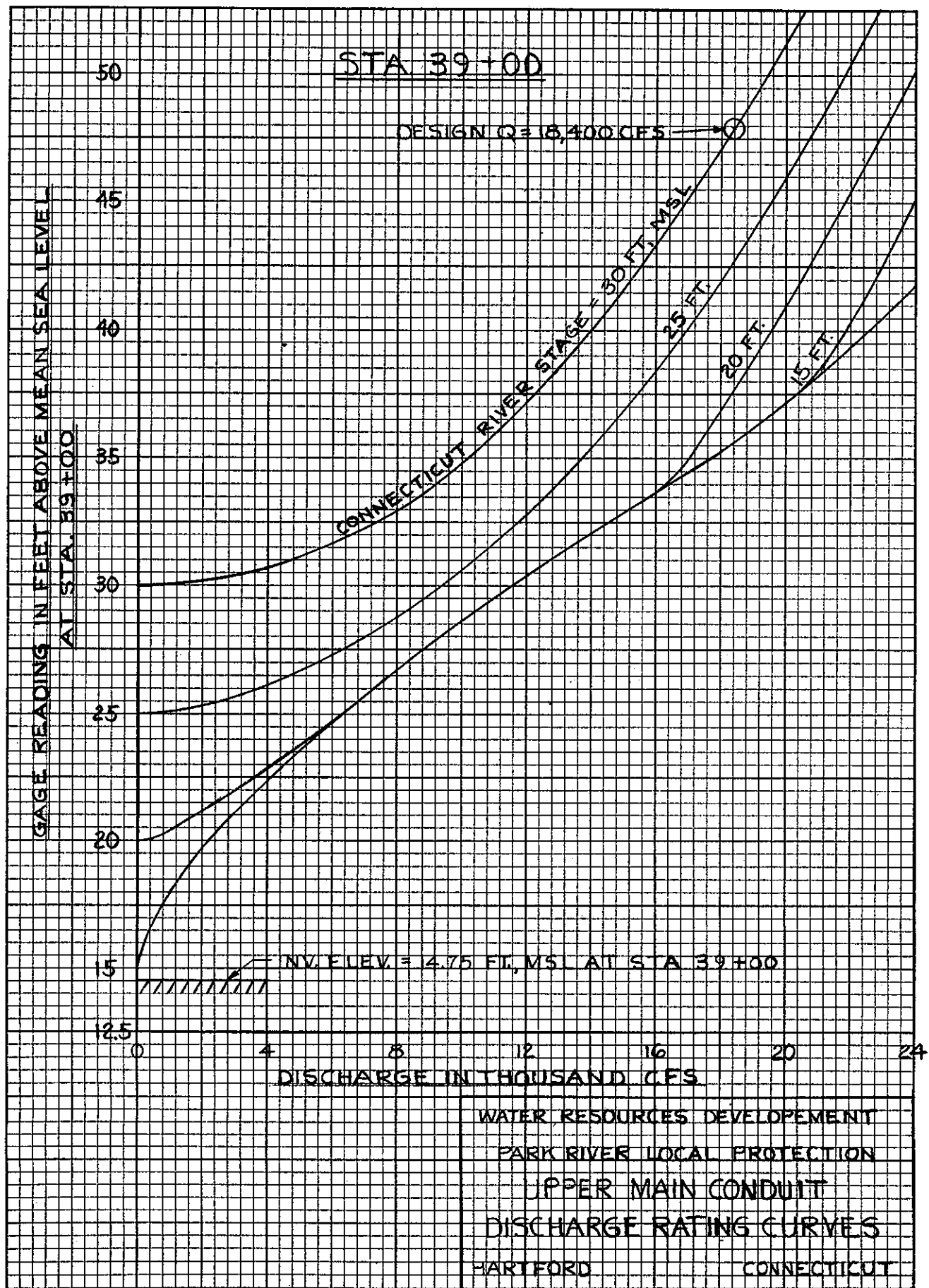


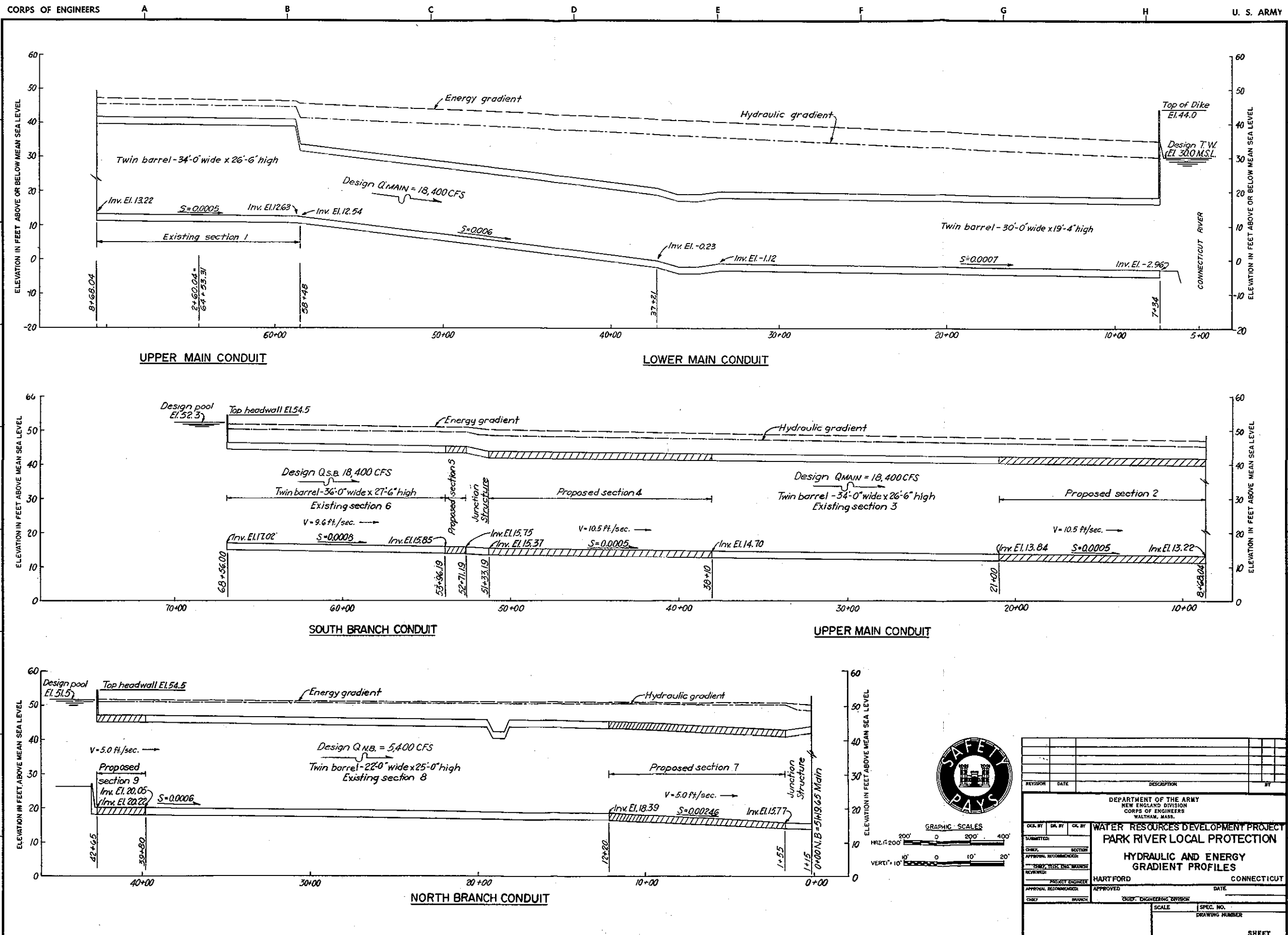


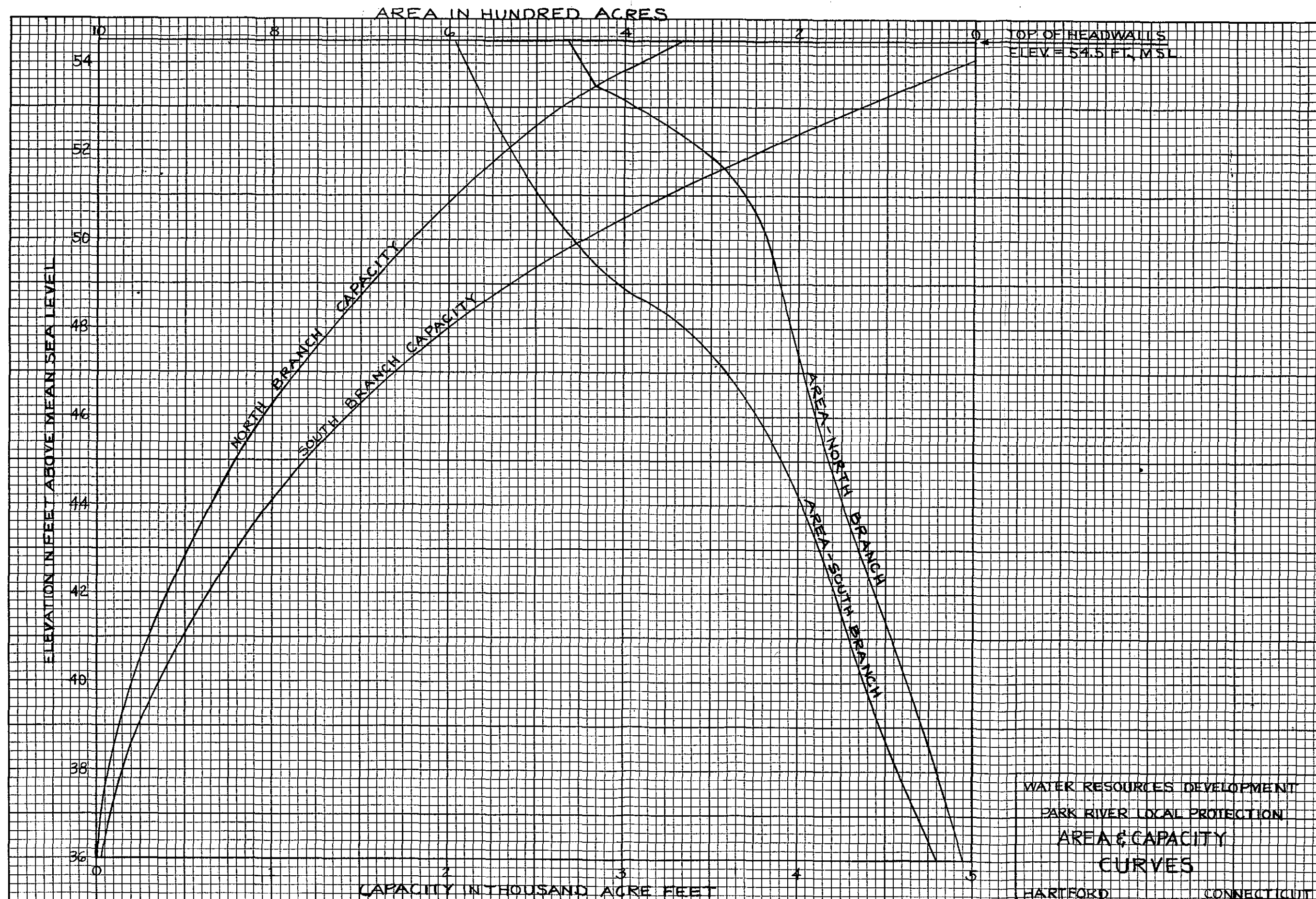


WATER RESOURCE DEVELOPEMENT
 PARK RIVER LOCAL PROTECTION
 NORTH & SOUTH BRANCH CONDUITS
 DISCHARGE RATING CURVES
 HARTFORD CONNECTICUT



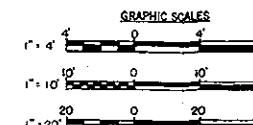
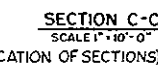
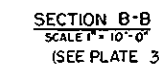
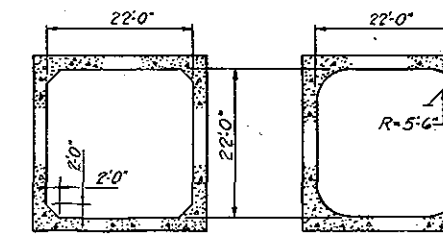
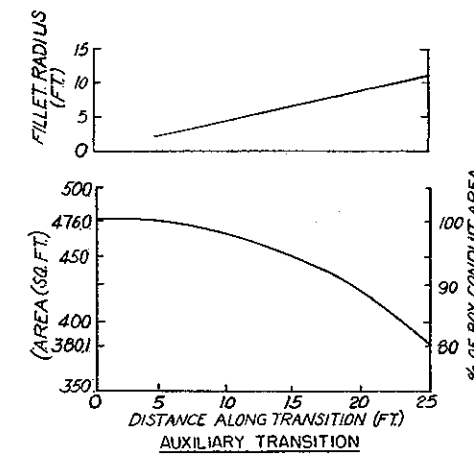
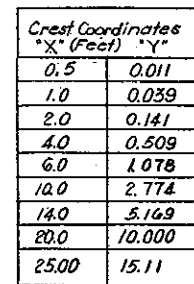
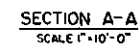


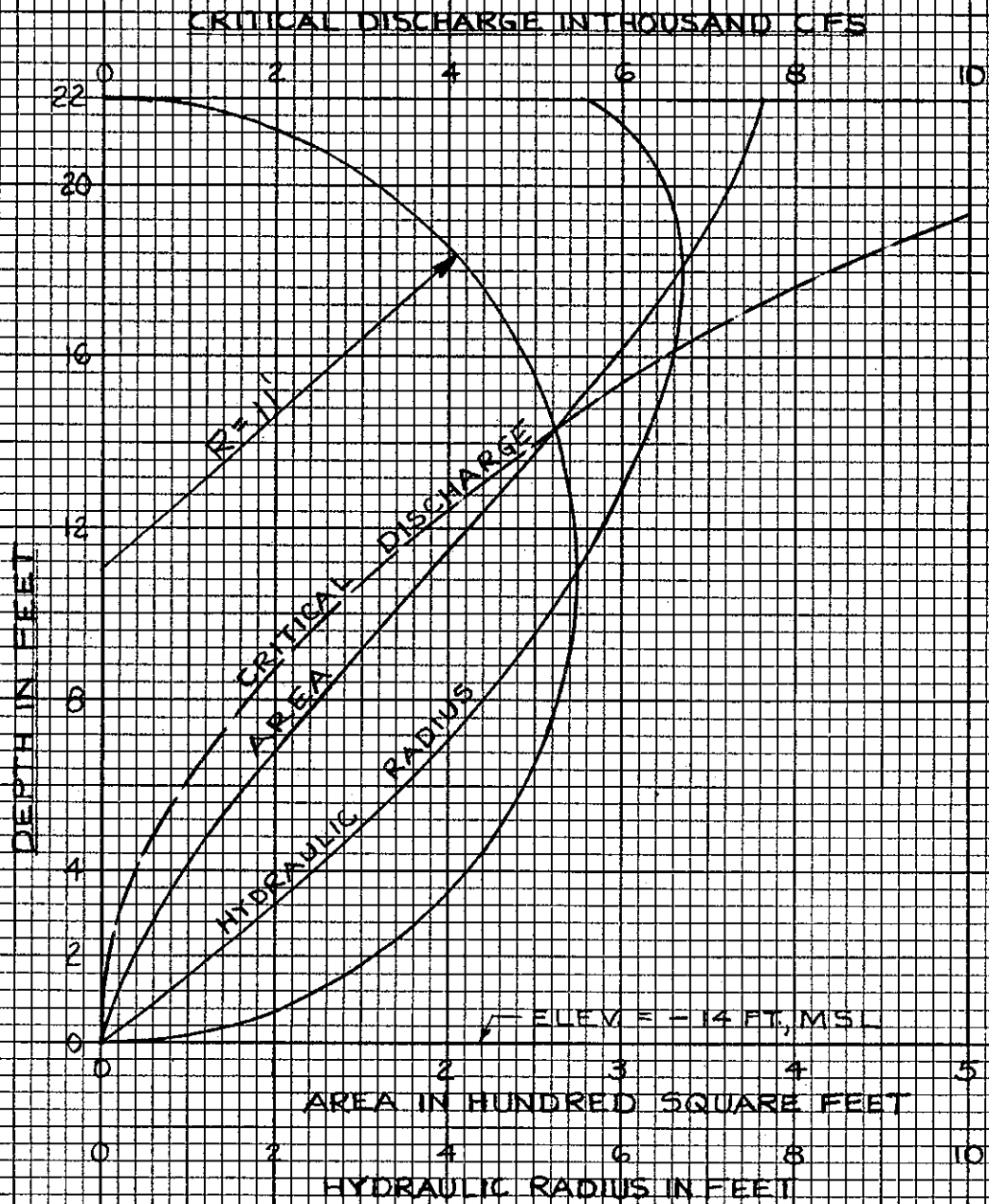




WATER RESOURCES DEVELOPMENT
 PARK RIVER LOCAL PROTECTION
 AREA & CAPACITY
 CURVES



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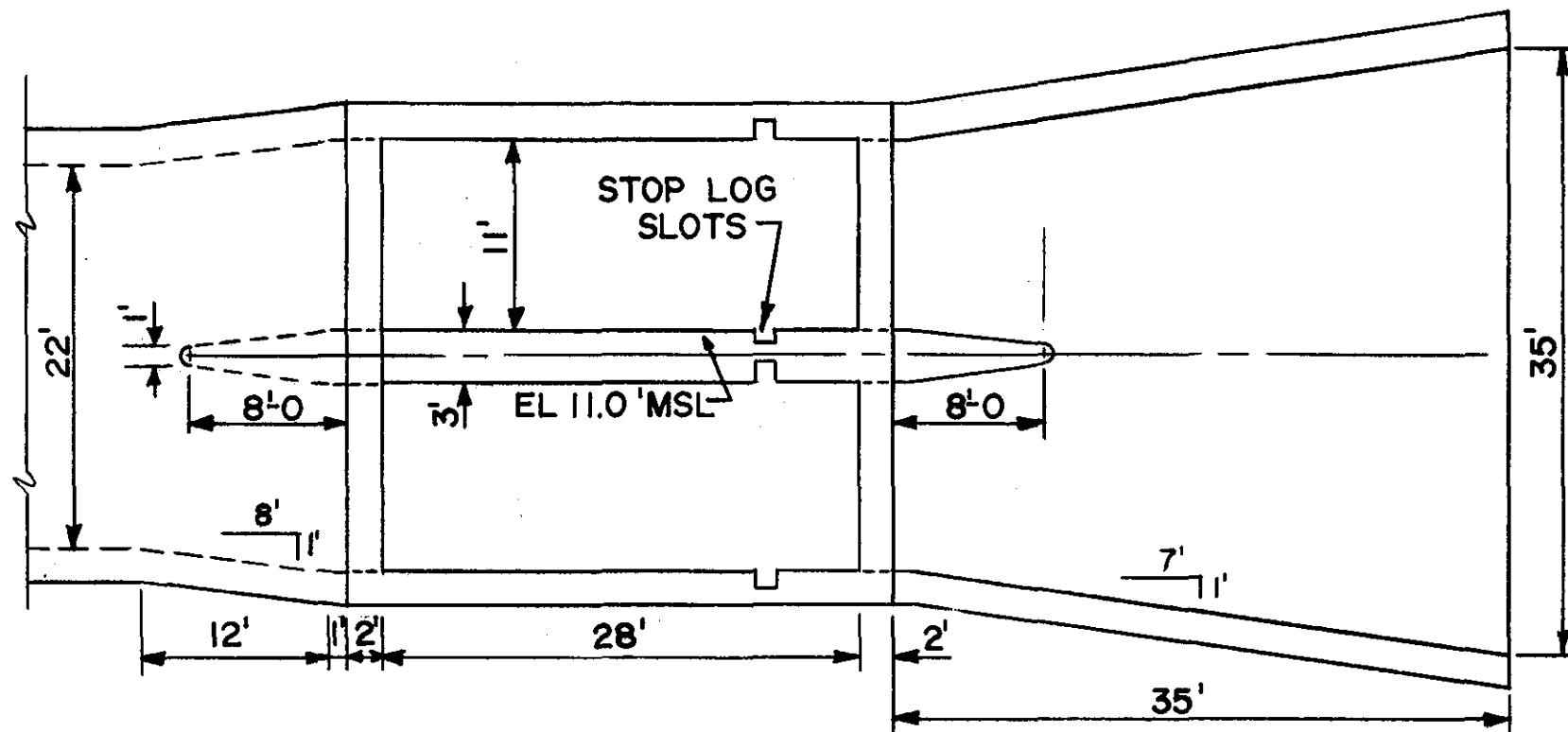


WATER RESOURCES DEVELOPEMENT
 PARK RIVER LOCAL PROTECTION
 AUXILIARY CONDUIT
 HYDRAULIC ELEMENTS

HARTFORD

CONNECTICUT

PLATE 3-18



PLAN
SCALE 1" = 10'



WATER RESOURCES DEVELOPMENT
PARK RIVER LOCAL PROTECTION

AUXILIARY OUTLET

HARTFORD

CONNECTICUT

APPENDIX
HYDRAULIC MODEL STUDY

HYDRAULIC MODEL STUDY
PARK RIVER
CONDUIT JUNCTION STRUCTURE

CONTRACT NUMBER DACW 33-73-C-0064

for

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS



ALDEN RESEARCH LABORATORIES

July, 1974

71-74/M231AF

HYDRAULIC MODEL STUDY
PARK RIVER
CONDUIT JUNCTION STRUCTURE

CONTRACT NUMBER DACW 33-73-C-0064

for

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS

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July, 1974

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ABSTRACT

A model of the Park River Conduit Junction Structure, located in Hartford, Connecticut, was built at the Alden Research Laboratories for the Department of the Army, New England Division, Corps of Engineers under contract reference DACW 33-73-C-0064 (see Figure 1).

The principle objective was to optimize the location of the Park Street auxiliary conduit at the junction of the North and South Branches of the Park River conduit and to develop, if necessary, the appropriate piers or geometric modifications required to insure satisfactory flow distribution with minimum hydraulic losses.

Test results indicated that the Park River junction with the addition of the auxiliary conduit structure, modified as shown in Figures 3 and 4, and as described in this report was hydraulically adequate for the design flow rate.

INTRODUCTION

Hydraulic tests were conducted on a 1:25 scale model of the Park River junction with the addition of the auxiliary conduit. The test program was conducted for and with the cooperation of the Department of the Army, New England Division, Corps of Engineers.

The model design and testing program were developed with the following objectives in mind:

- A) to verify that the Park River junction will operate effectively with the addition of the auxiliary conduit,
- B) to optimize the location of the entrance of the auxiliary conduit at the junction,
- C) to develop, if necessary, the appropriate piers or geometric modifications required to produce satisfactory flow distribution with minimum hydraulic losses.

The test program included visual inspection of flow patterns, flow rate measurement, and water depth measurements in order to determine the hydraulic gradient.

DESCRIPTION OF PROTOTYPE

The Park River conduit junction structure will be located at the confluence of the North and South Branch conduits of the Park River local protection project in the central part of Connecticut. A general plan of the project is given in Figure 2.

The North Branch consists of two parallel rectangular concrete underground conduits, each 22 feet wide and 25 feet deep. The South Branch consists of two parallel rectangular conduits, each 36 feet wide and 27.5 feet deep. The two primary conduits discharging from the junction are the Park River conduits each 34 feet wide by 26.5 feet deep. The auxiliary conduit is an underground circular conduit, 22 feet in diameter, which also discharges from the junction through a drop structure (Figure 4).

The maximum design flow rate for the South Branch was 17,300 cfs and for the North Branch was 7,700 cfs.

SIMILITUDE AND SCALING CRITERIA

The linear geometric scale between model and prototype was 1:25. The slope ratio between model and prototype was 4:1. Geometric scale selection for the model was based on several factors:

- A) The model was to be small enough to fit inside a building and be economically constructed.
- B) The model was to be uniform (same horizontal and vertical scales) and large enough to satisfy Reynolds and Froude scaling criteria.

Since inertia and gravity forces dominate the flow in this situation, Froude scaling was used to relate the model to the prototype. It was also desirable to maintain a Reynolds number well into the turbulent range for the model to duplicate the flow characteristics of the prototype.

The expressions for the Froude and Reynolds number are respectively:

$$F = \frac{V}{\sqrt{gL}} \qquad R = \frac{VL}{\nu}$$

where

- L = characteristic length
- V = velocity
- g = gravitational acceleration
- ν = kinematic viscosity

The equality of the model (m) and the prototype (p) Froude numbers expresses the Froude scaling criterion:

$$F_m = F_p$$

On substituting the length ratio 1:25 and noting that $g_m = g_p$, the velocity ratio becomes:

$$\frac{V_m}{V_p} = \left(\frac{1}{25} \right)^{1/2} = \frac{1}{5.0}$$

From this procedure the other relevant scaling ratios can be determined, giving:

length ratio	1:25
area ratio	1:625
volume ratio	1:15625
flow ratio	1:3125
velocity ratio	1:5

The slope ratio was selected using a Froude-Manning formula combination in order to offset the relative roughness criteria between the model and prototype.

$$n_r = L_r^{1/6}$$

where $n_r = \frac{n_m}{n_p}$ and n = Manning's n

$$L_r = \frac{L_m}{L_p} = \frac{1}{25}$$

Assuming $n_p = 0.011$ (for a concrete conduit) it can be seen that a model Manning's n of 0.00643 is necessary for model-prototype similitude. Since it is practically impossible to obtain a Manning's n of this magnitude the slope ratio of model to prototype was adjusted in order to offset the roughness criteria.

$$V = \frac{1.49}{n} R^{2/3} S^{1/2} \quad \text{Manning formula}$$

where

R = hydraulic radius

S = slope

From Froude scaling criteria:

$$F_m = F_p$$

therefore,

$$\frac{V_m}{\sqrt{g_m L_m}} = \frac{V_p}{\sqrt{g_p L_p}}$$

substituting the Manning formula for velocity and noting that $g_m = g_p$ and

$R_R = \frac{R_m}{R_p} = \frac{1}{25}$ an equation for the slope ratio is determined:

$$S_R = \frac{S_m}{S_p} = \frac{n_r^2}{L_r^{1/3}}$$

Solving for the slope ratio, assuming the painted fiberglass surface to have a Manning's $n = 0.013$, results in $S_R = 4.0$.

MODEL DESCRIPTION

The basic model was constructed according to prototype dimensions provided by the Corps of Engineers, and occupies an area approximately 50 feet by 80 feet.

The individual conduit dimensions are based upon $L_R = 1:25$ and are as follows:

North Branch	10.5" wide x 12" deep
South Branch	17.25" wide x 13.25" deep
Park branch	16.375" wide x 12.75" deep
Auxiliary conduit	10.5" I.D. pipe

The model included 625 feet of the North Branch and 875 feet of the South Branch prior to their confluence at the Park River junction. Immediately downstream of the junction 750 feet of the Park branch and 600 feet of the auxiliary conduit were modeled.

The conduits were constructed with a combination of plywood, fiberglass matting and epoxy paint. The top of each wall was flanged to provide a means of installing a 1/4" thick clear lucite top for the pressurized conduit tests.

During the initial testing with the roof in place, it was noticed that as the conduits become full and pressurized, entrapped air gulped down the South Branch conduits causing surging in the area of the junction. An air vent was put in the roof over each conduit of the South Branch 0.4 feet upstream of the junction. Each vent was 2-5/8 inches high by 2-3/8 inches long by the full width of each conduit. A 1/2 inch I.D. vertical pipe was placed in the center of each vent. (See Photo No. 1).

The junction section of the model was constructed from clear lucite with the top and side sections removable in order to allow access to the interior of the junction.

The auxiliary entrance and drop structure were also constructed primarily from clear lucite. The use of lucite permitted visual observation of the flow patterns in pertinent areas. Two other auxiliary entrance configurations were tested before arriving at the present configuration. The first configuration consisted

of the auxiliary conduit connecting directly to the junction side wall at a 90° angle (Figure 5). The second configuration involved the use of a 25' x 50' elliptical junction wall leading into a rectangular to circular transition piece (Figure 6).

The final configuration utilizes the elliptical entrance wall leading into the drop structure. The floor of the entrance was modified to include a 3' high weir along the junction side wall. At the end of the drop structure a rectangular to circular transition piece precedes the circular auxiliary conduit.

An air vent 0.4 feet long by 0.88 feet wide was located over the drop structure and was tested for several sized openings (Figure 4).

The entire model structure was supported on steel I beams approximately 30" off of the floor.

The various piers or geometric modifications required to modify flow patterns during testing were made of wood.

Figure 1 shows the water supply system for the model. Water is pumped from a sump to a head tank, from there water is withdrawn through a 12" diameter pipe with a flow regulating valve to each head tank at the beginning of the South and North Branches. The flow rate for the South Branch is measured by an orifice plate in the inlet piping, the flow rate for the North Branch is measured by two calibrated sharp crested weirs.

Control boxes were also installed at the downstream end of the Park branch and the auxiliary conduit, each box containing a point gauge used to monitor the flow rate. Piezometers installed, as shown in Figures 7 and 8, were used to measure the static pressure head along the center line of each conduit and through the junction.

TEST PROCEDURE

The purpose of the model was to verify the hydraulic suitability of the structure and to insure that it would perform hydraulically in a satisfactory manner for all expected flow conditions. Testing was performed to document the observations with measurements of water depth and flow rates and sketches of various flow patterns. The weir levels were adjusted to give specific depths at reference station 45 + 63.08 (see Figure 9).

Each test series commenced with the following procedure:

- A) Adjust the Park Weir in the Park branch control box to the desired level.

- B) Adjust the Auxiliary Weir in the auxiliary conduit control box to the desired level.
- C) Adjust the South Branch flow to the desired rate. (The flow rate was monitored with a manometer connected across an orifice plate located in the pipeline feeding of the South Branch constant head box.) (Figure 1)
- D) Adjust the North Branch flow rate to the desired level. (The flow rate was monitored with point gauges measuring the water depth flowing over a calibrated weir.)
- E) Bleed all manometers to remove air entrapped in the lines.

Preliminary model tests were conducted to check the operation of the model and to insure that the model flows and water depths could be properly controlled and measured. These tests provided an opportunity to check the instrumentation and to establish measurement and recording procedures.

Flow Rates and Water Depth Measurements

After the above procedure was completed, the water depth measurements were recorded from manometers connected to the piezometers located in each branch of the model. Flow rates in the Park branch control box and the auxiliary conduit control box were then recorded. Finally the flow rates in the South Branch and the North Branch were rechecked and recorded.

Flow Patterns

In addition to the water depth and flow rate measurements, the flow patterns in the junction area of the model were observed using paper chips and dye.

All test measurements were made after a suitable time interval to allow equilibrium conditions to develop.

TEST RESULTS

Preliminary model tests were performed with the original auxiliary entrance configuration as shown in Figure 5. This configuration was immediately discarded due to flow separation in the entrance area of the auxiliary conduit resulting in a high head loss (see Photo 2 and 3).

The auxiliary entrance structure was then modified by installing a 25' x 50' elliptical junction wall leading into a rectangular to circular transition piece (Figure 6). The second auxiliary entrance configuration was hydraulically satisfactory and tests were performed using various pier configurations and channel wall extensions, in the junction area, in order to determine the optimum configuration to minimize hydraulic losses. Test results obtained from dye studies determined the configuration as shown in Figure 3 to be the optimum configuration.

The third auxiliary entrance configuration utilizes the elliptical junction wall leading into the drop structure. At the end of the drop structure a rectangular to circular transition piece precedes the auxiliary conduit. The floor of the auxiliary entrance was also modified by installing a weir as shown in Figure 4. A series of tests were performed on the third auxiliary entrance configuration in order to investigate the hydraulic suitability of the structure. The South Branch flow rate and the North Branch flow rate were adjusted to design conditions while the Park branch and auxiliary conduit weirs were set to levels determined in preliminary tests. A summary is given in Tables 1 and 2.

The fourth auxiliary entrance modification was to block the auxiliary conduit at the end of the elliptical junction wall. This was performed in the event that the installation of the auxiliary conduit is done after the junction structure was completed. Test results are summarized in Table 3.

Tabulations and plots of the hydraulic gradient data for pertinent test runs are included at the end of this report.

Preliminary tests indicated a need for air vents in the South Branch and over the drop structure. Air vents were installed but no attempt was made to size them. After the installation of the air vent in the South Branch the surging in the junction was reduced.

Photos 9-12 were taken of the drop structure area for the design flow rate at the minimum and intermediate weir levels with the air vent open and with the air vent blocked off using styrofoam. These runs were not conclusive as to air demand of the vent.

CONCLUSIONS

The results of the tests conducted in this model study showed:

- a) That the Park River Junction as modified will operate effectively with the addition of the auxiliary conduit.
- b) That the location of the entrance of the auxiliary conduit at the junction is optimized.
- c) The appropriate piers and geometric modifications produce satisfactory flow distribution with minimum hydraulic losses.

Although sizing air vents was not a part of this study, it was found that air vents are needed in the South Branch upstream of the junction and over the drop structure.

The results of the tests conducted in this model study showed that the final design, as described in this report of the Park River junction and auxiliary conduit structure, was hydraulically adequate for the flow rates and weir water levels indicated.

PHOTOGRAPHS

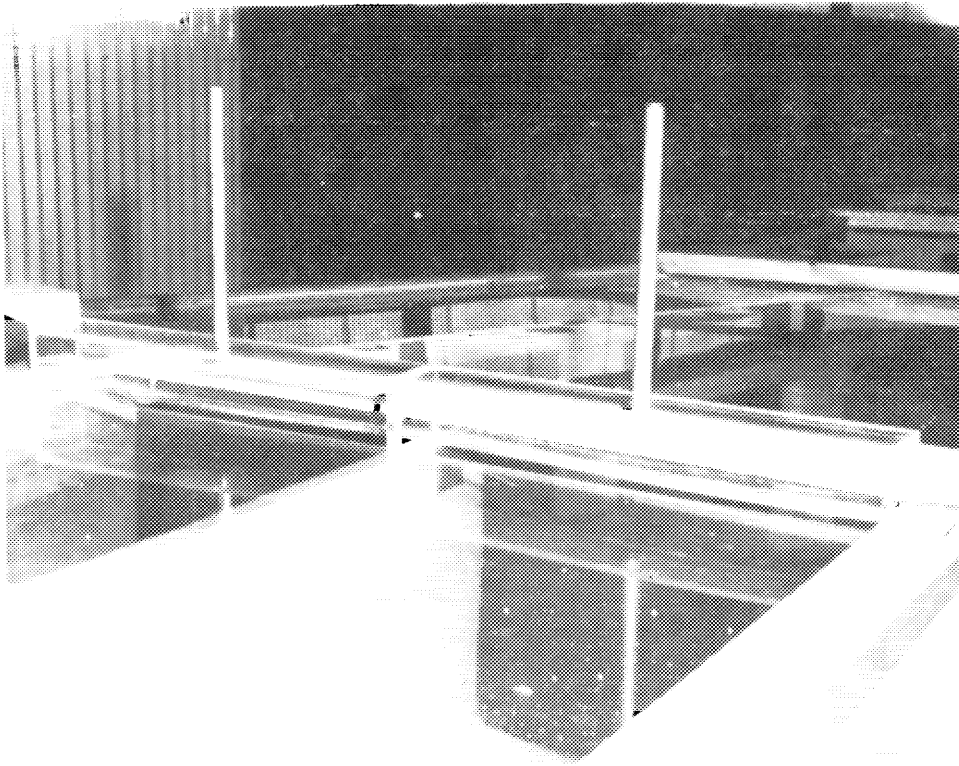


Photo No. 1 Air Vent in South Branch

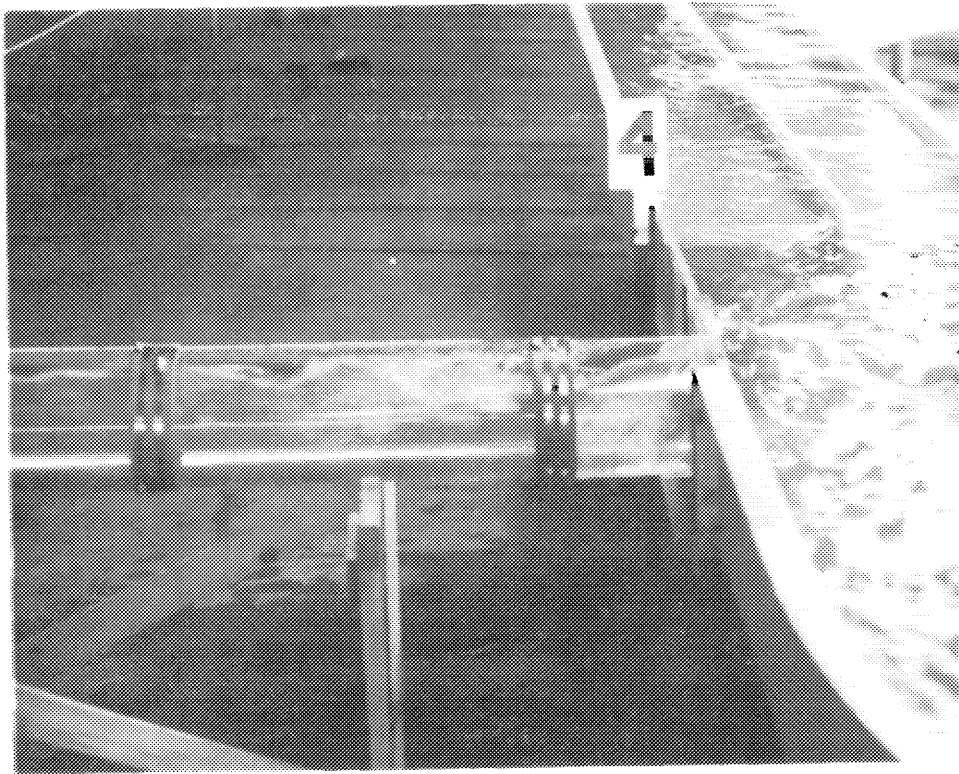


Photo No. 2 Original Auxiliary Entrance

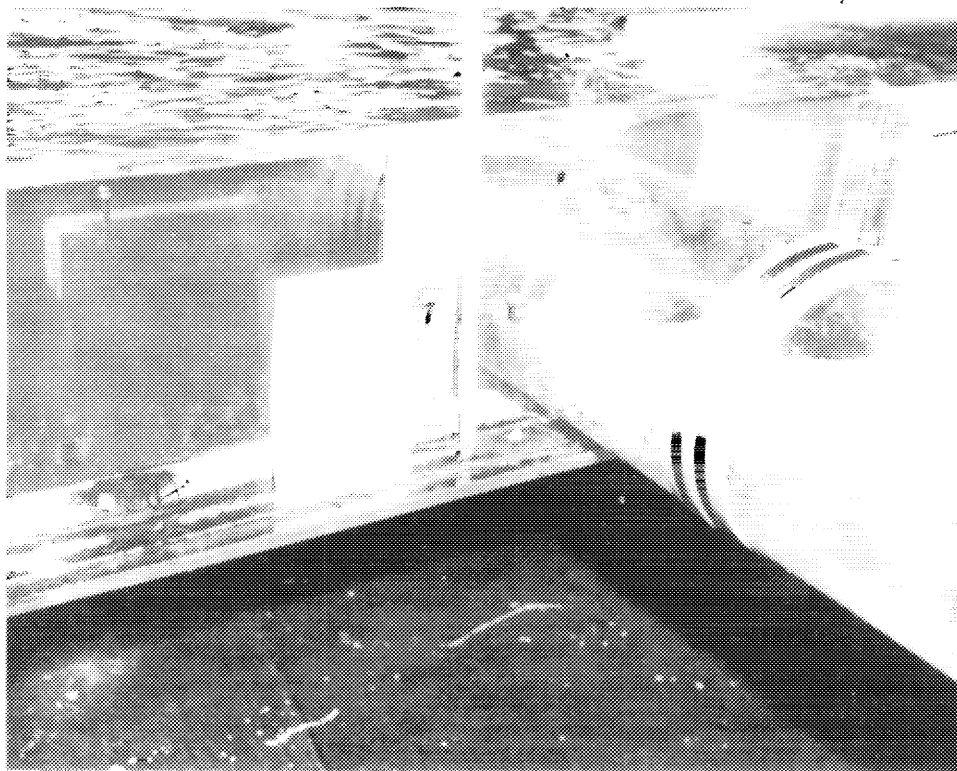


Photo No. 3 Original Auxiliary Entrance

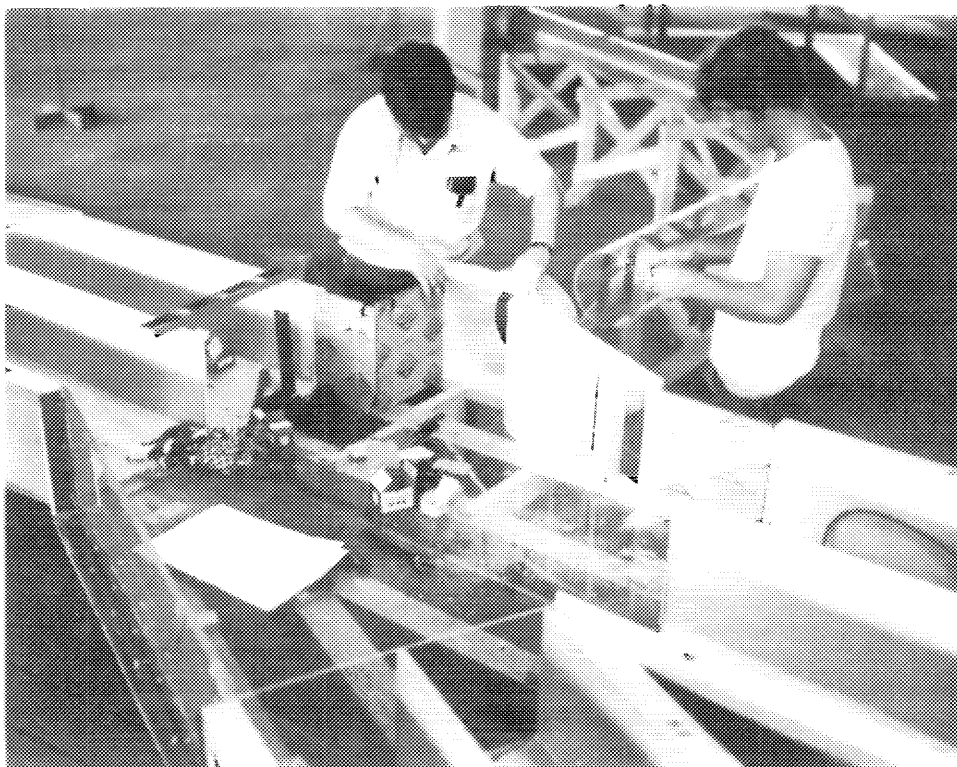


Photo No. 4 Elliptical Auxiliary Entrance

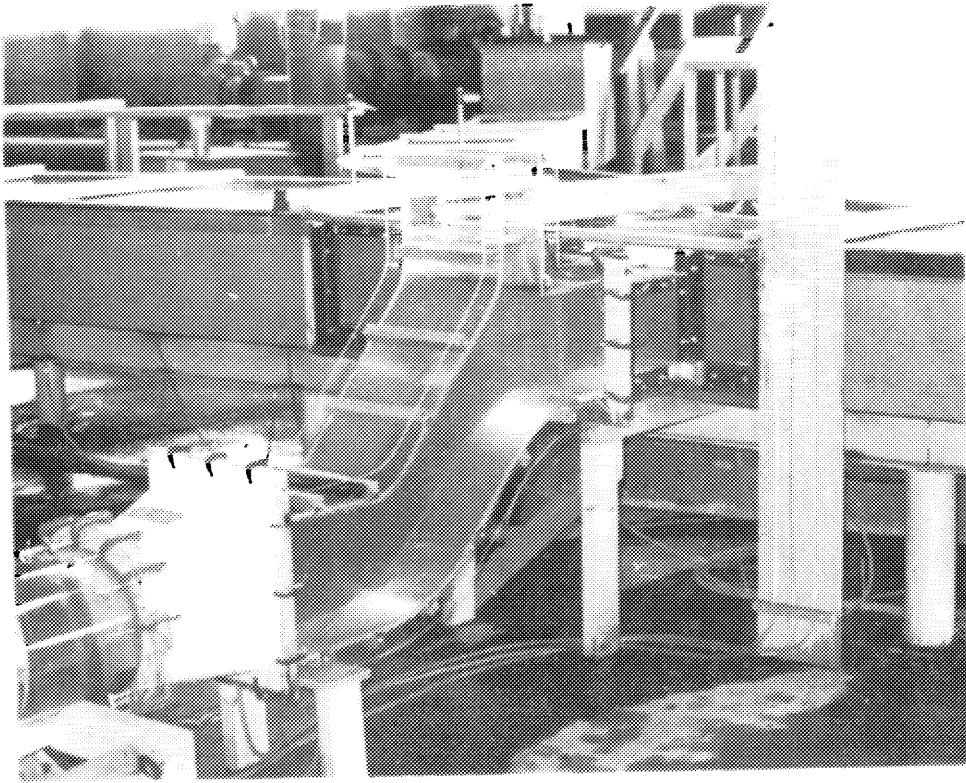


Photo No. 5 Drop Structure

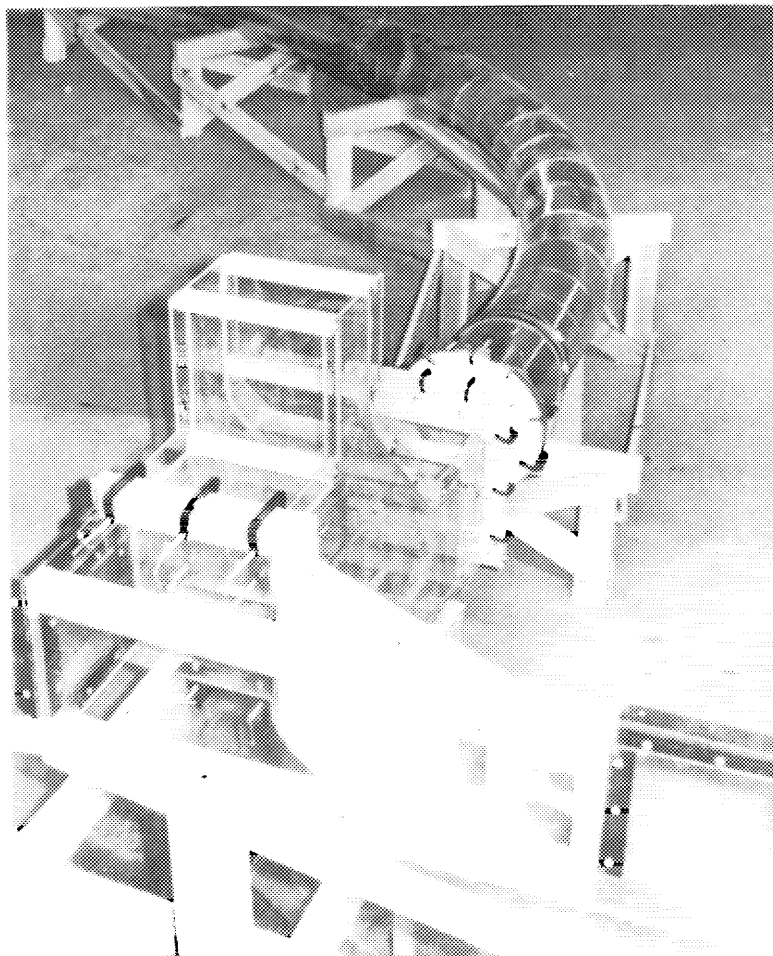


Photo No. 6 Auxiliary Conduit from Junction
Structure

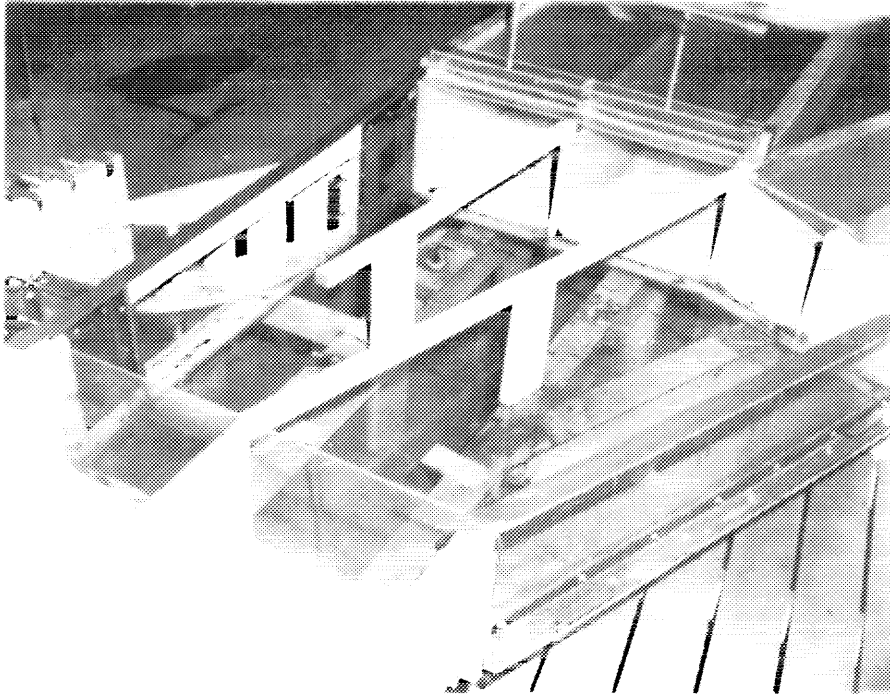


Photo No. 7 Junction Support Structures

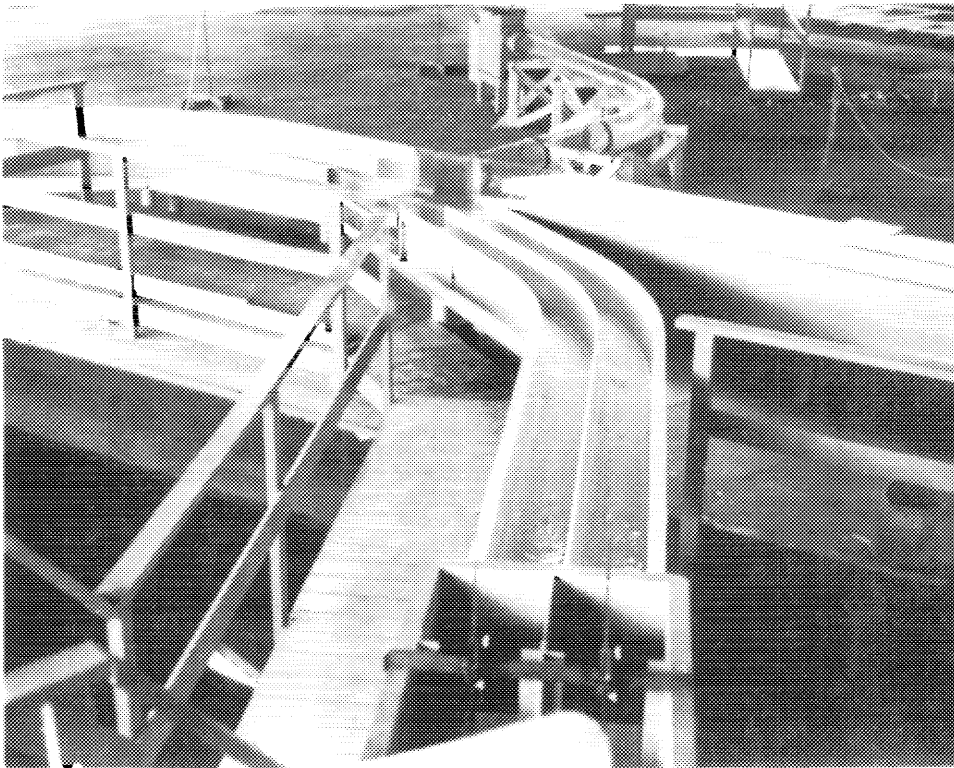


Photo No. 8 Park River Conduit Junction Structure

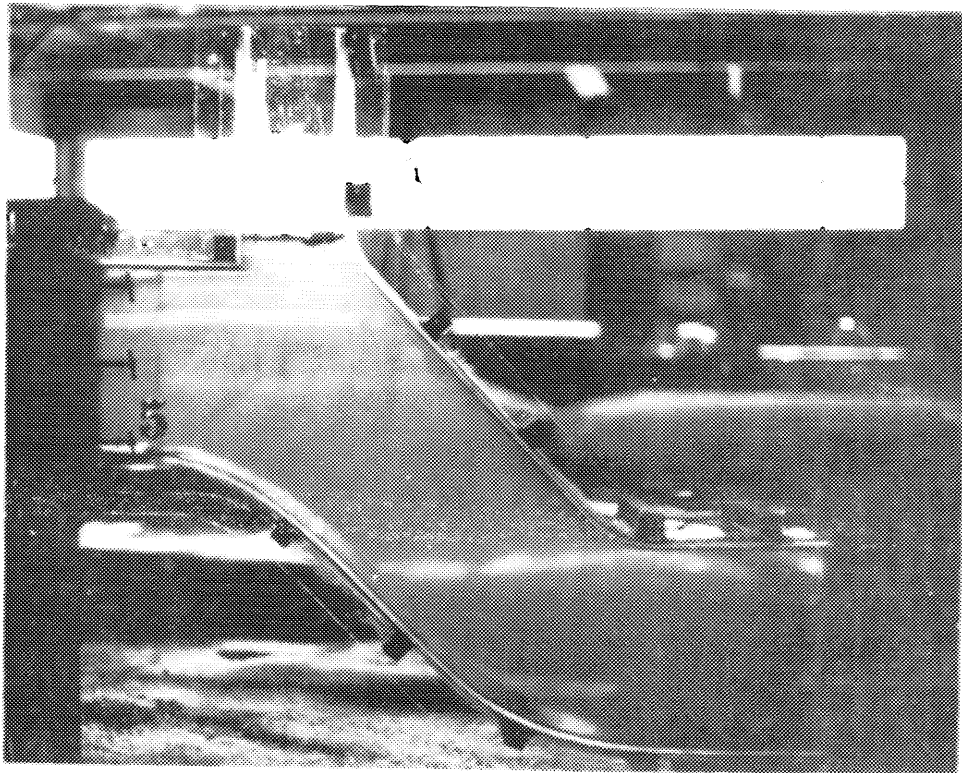


Photo No. 9 Intermediate Weir Level, Vent Open

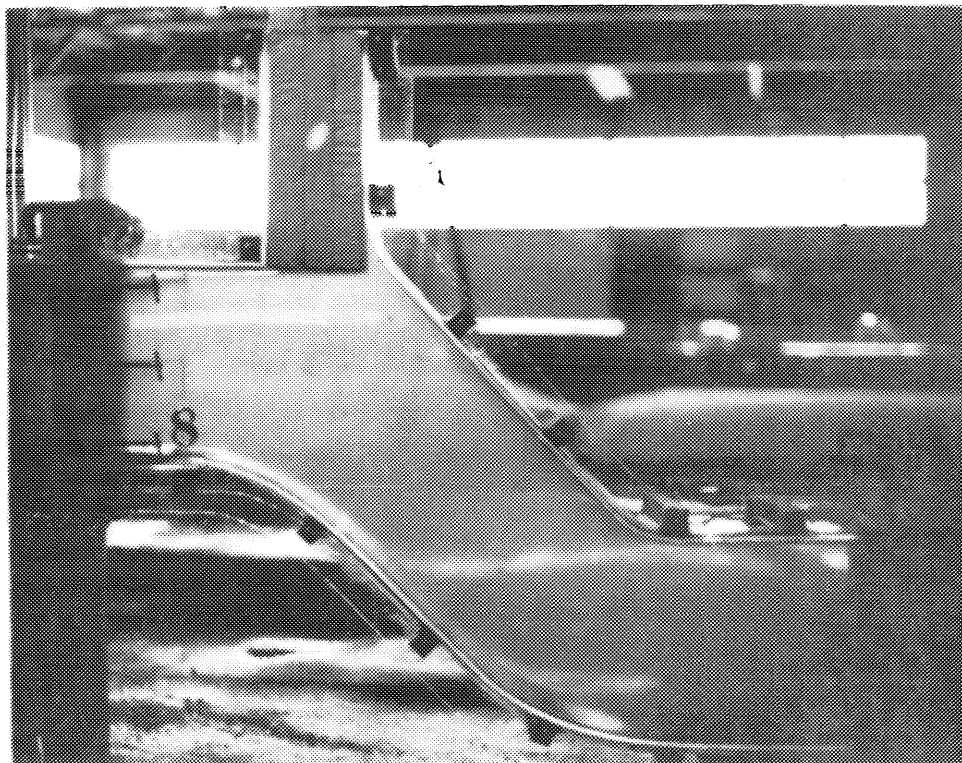


Photo No. 10 Intermediate Weir Level, Vent Closed

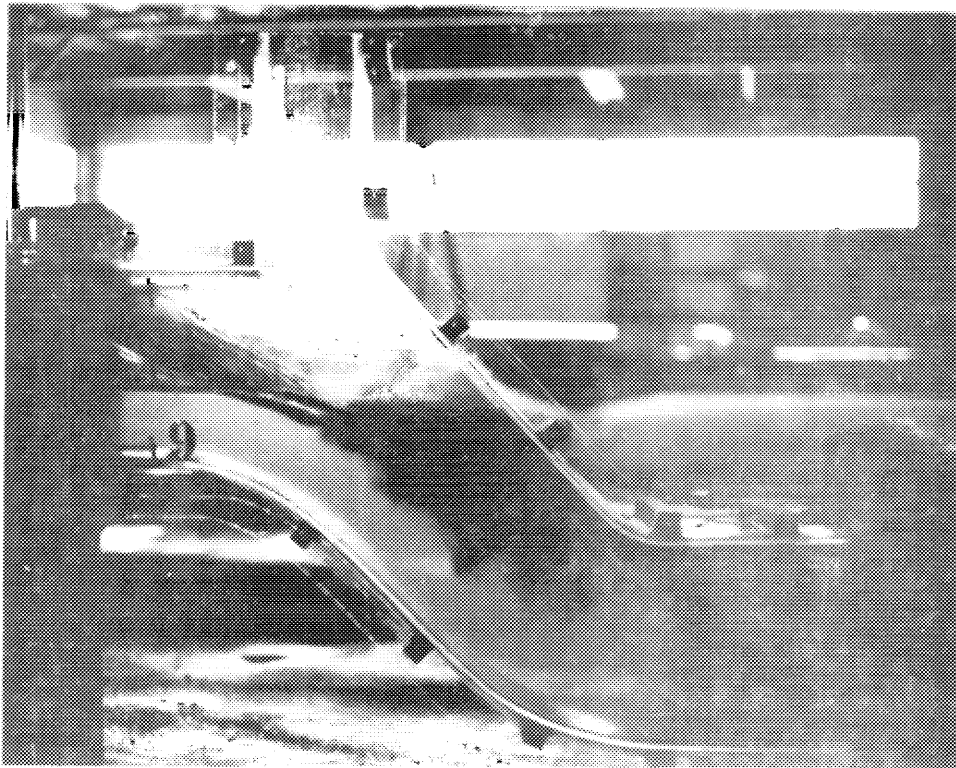


Photo No. 11 Minimum Weir Level, Vent Open

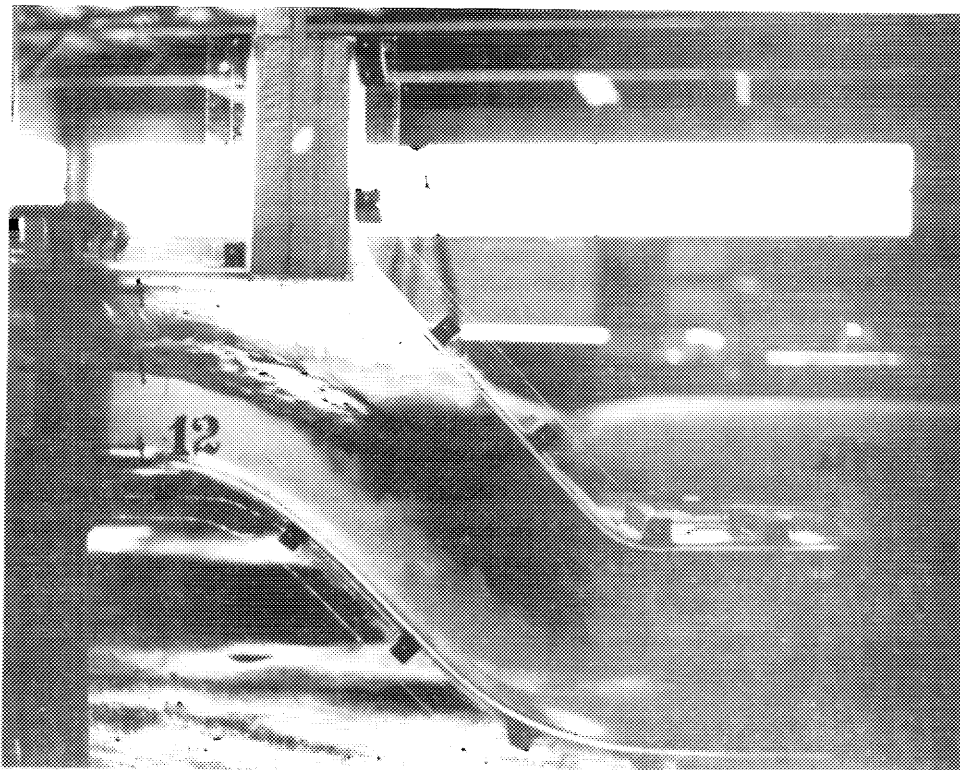


Photo No. 12 Minimum Weir Level, Vent Closed

TABLES

T A B L E 1

HYDRAULIC MODEL TEST PROGRAM

TEST NO.	WEIR LEVELS*		FLOW RATE CFS	
	Park branch	Aux. conduit	Park branch	Aux. conduit
124	Minimum	Minimum	17968	7032
125	Minimum	Intermediate	18230	6770
126	Minimum	Maximum	19683	5317
127	Intermediate	Minimum	16306	8694
128	Intermediate	Intermediate	17212	7788
129	Intermediate	Maximum	18591	6409
130	Maximum	Minimum	15530	9470
131	Maximum	Intermediate	16537	8463
132	Maximum	Maximum	17213	7787

South Branch Flow Rate = 17322 cfs

North Branch Flow Rate = 7690 cfs

(Park branch and aux.conduit weir levels are located in their respective control boxes as shown in Figure 1)

* Minimum Park Weir Level = 4.150' Relative to Ref. Point**
 Intermediate Park Weir Level = 9.400' Relative to Ref. Point
 Maximum Park Weir Level = 14.400' Relative to Ref. Point
 Minimum Auxiliary Weir Level = -12.075' Relative to Ref. Point
 Intermediate Auxiliary Weir Level = -4.75' Relative to Ref. Point
 Maximum Auxiliary Weir Level = +2.625 Relative to Ref. Point

**Reference Point as Described in Figures 9 and 10

HYDRAULIC MODEL TEST PROGRAM

[illegible]
$$Q_{\text{auxiliary}} = 5750 \text{ cfs}$$

** Reference Point as Described in Fig. 9 and 10

T A B L E 3

HYDRAULIC MODEL TEST PROGRAM

AUXILIARY CONDUIT BLOCKED AT END OF ELLIPTICAL WALL

Test No. 117

Depth of Water at Station Point 51 + 47*, $y_{1,12} = 17.725$ ft
 $y_{2,12} = 17.900$ ft

$Q_{\text{south}} = 9994$ cfs

$Q_{\text{north}} = 4040$ cfs

$Q_{\text{park}} = 14000$ cfs

Park branch Weir Level = +3.15 ft Relative to Reference Point**

* See Figure 7

** Reference Point as Described in Fig. 9 and 10

Test No. 119

Depth of Water at Station Point 51 + 47*, $y_{1,12} = 33.00$ ft
 $y_{2,12} = 33.55$ ft

$Q_{\text{south}} = 12014$ cfs

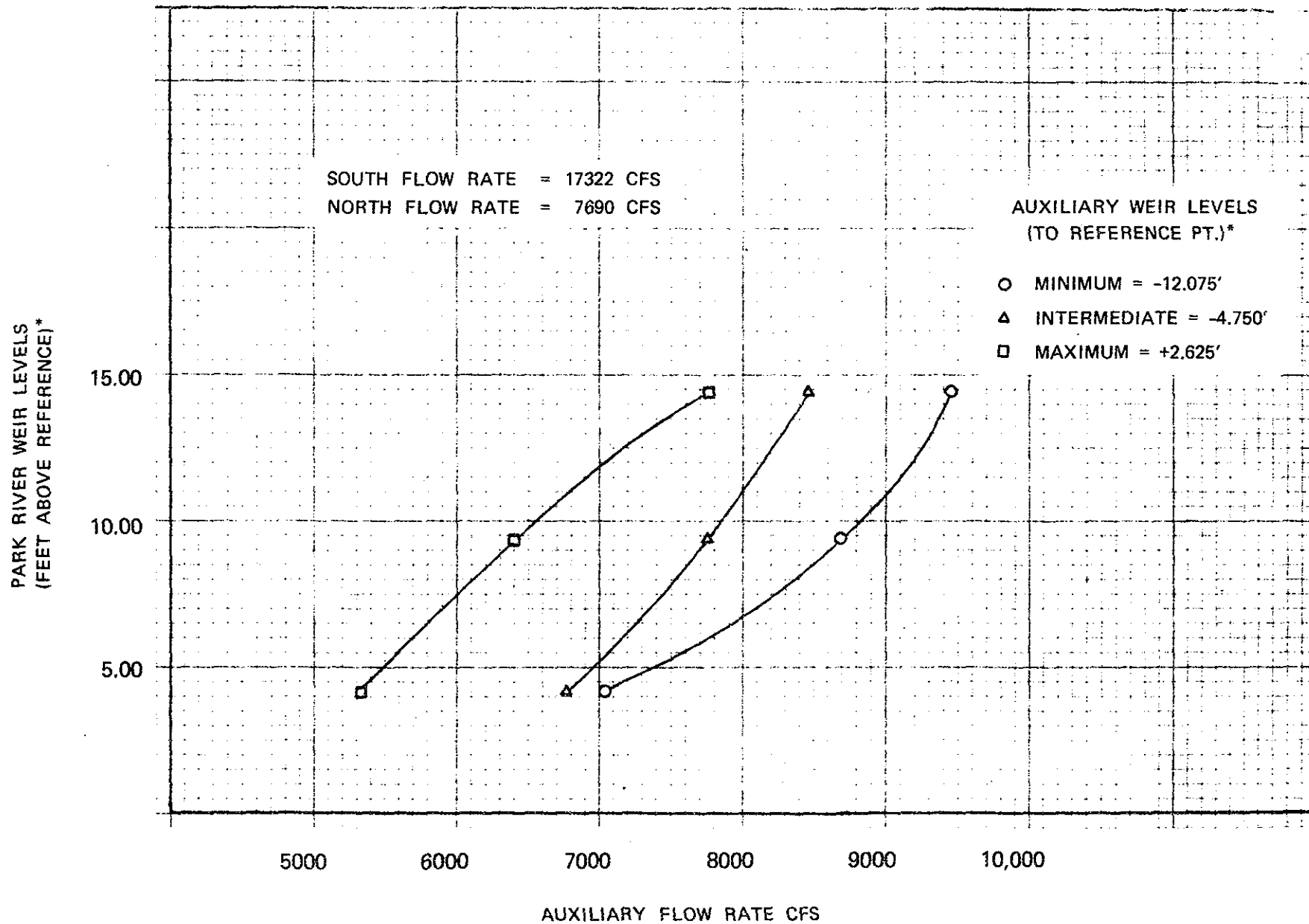
$Q_{\text{north}} = 6065$ cfs

$Q_{\text{park}} = 18079$ cfs

Park branch Weir Level = +15.15 ft Relative to Reference Point**

* See Figure 7

** Reference Point as Described in Fig. 9 and 10



FLOW RATES (TESTS 124-132)
PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY

* REFERENCE AS DESCRIBED IN FIGURES 9 AND 10

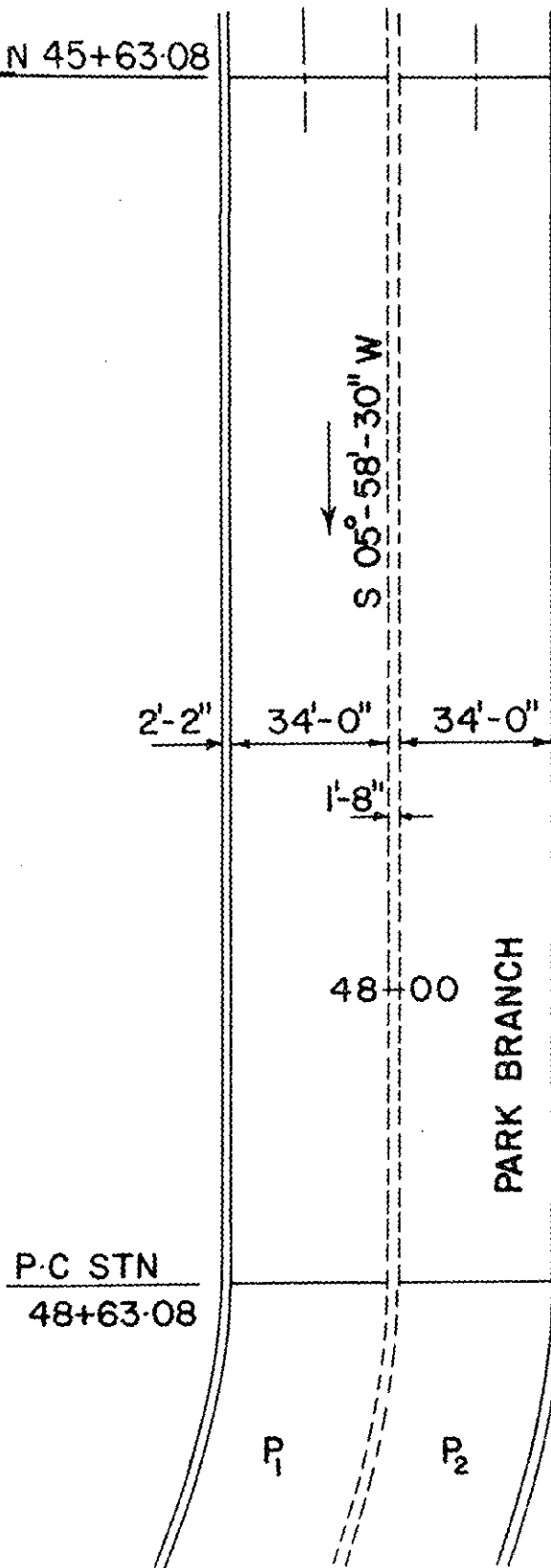
AND

FIGURES

STN 45+63.08

REFERENCE POINTS

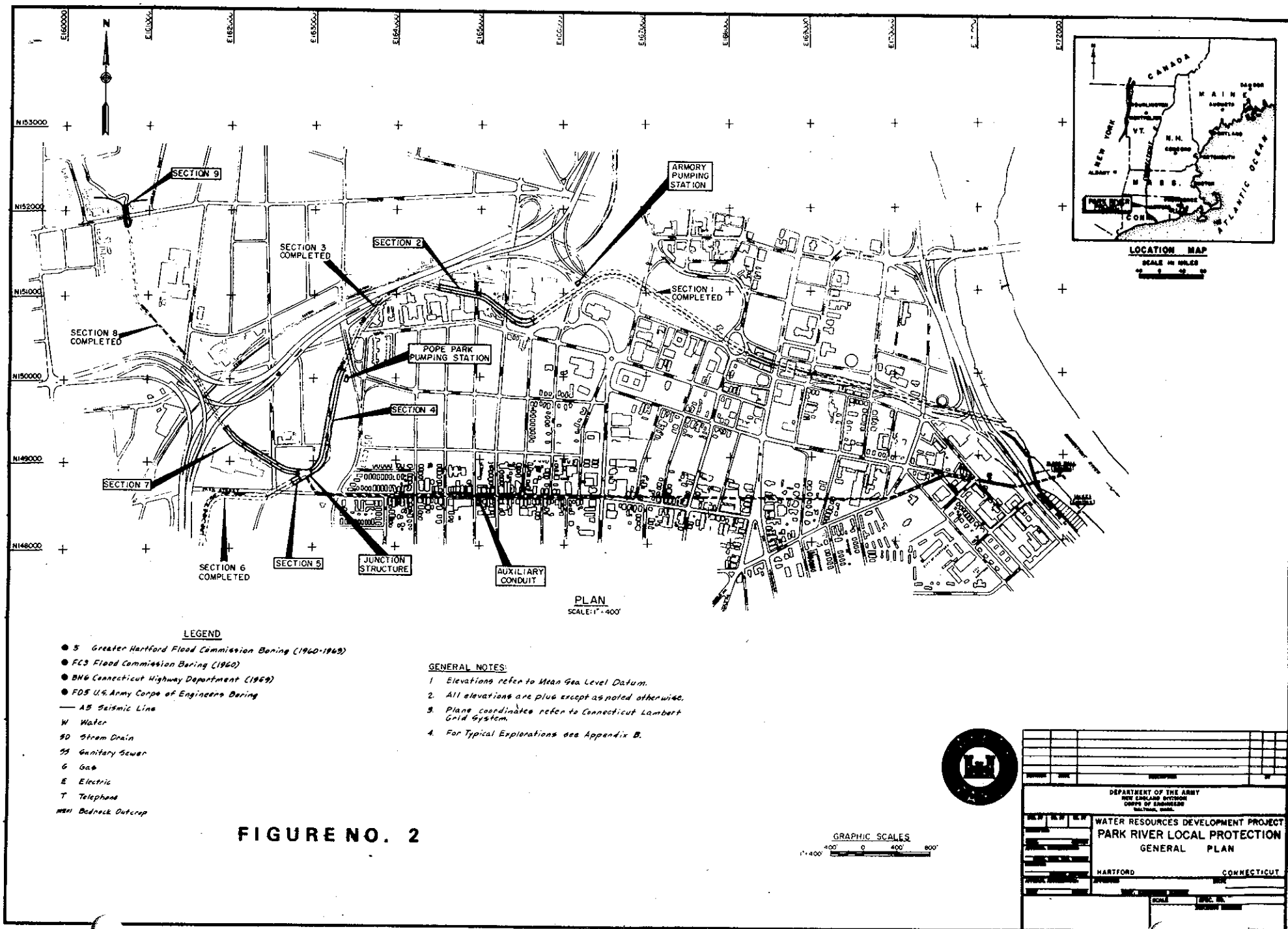
(SEE FIGURE NO. 10)



REFERENCE POINT LOCATION
PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY

FIGURE NO. 9

ARL



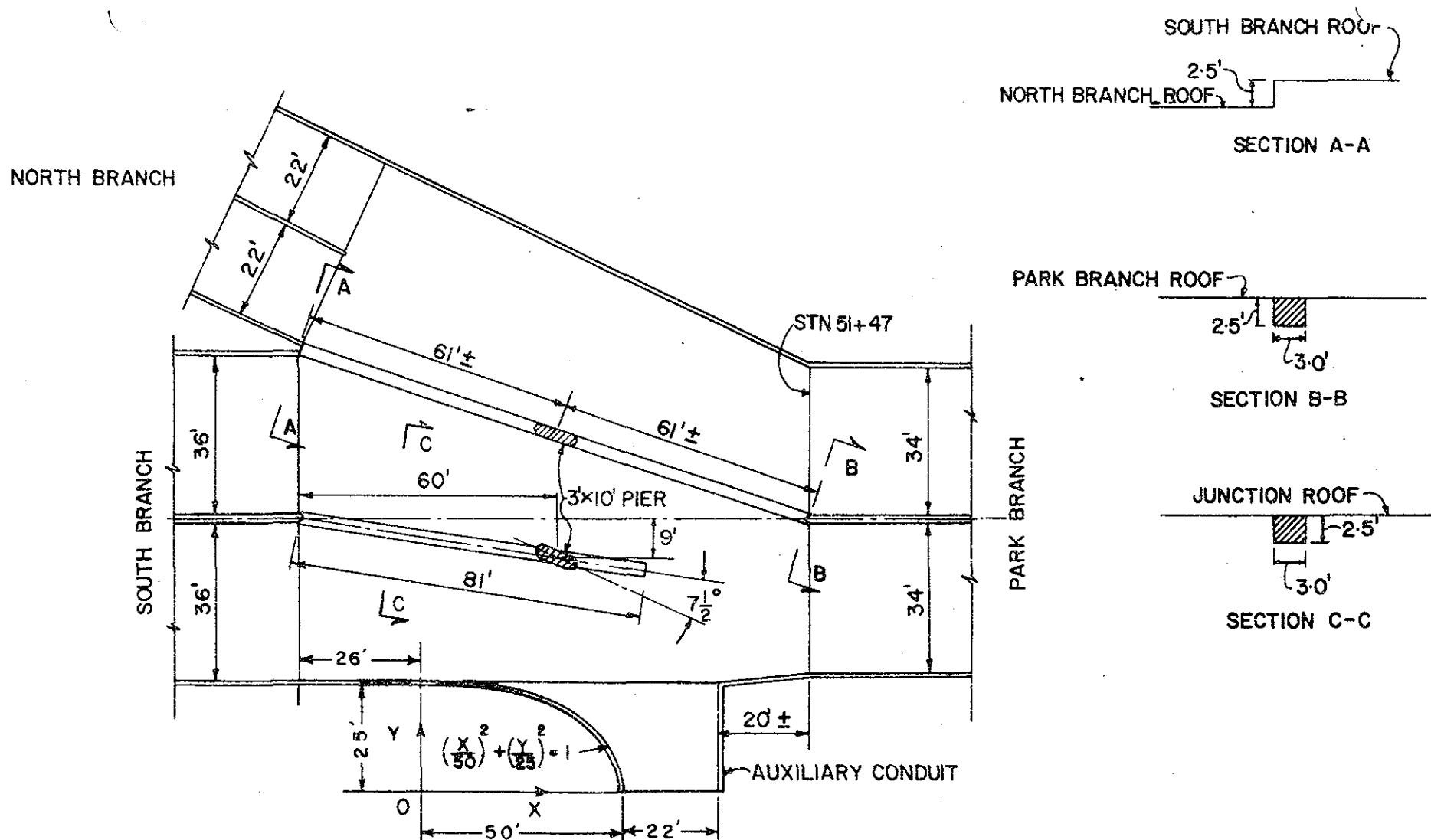


FIGURE NO. 3

DETAILS OF JUNCTION STRUCTURE
PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY

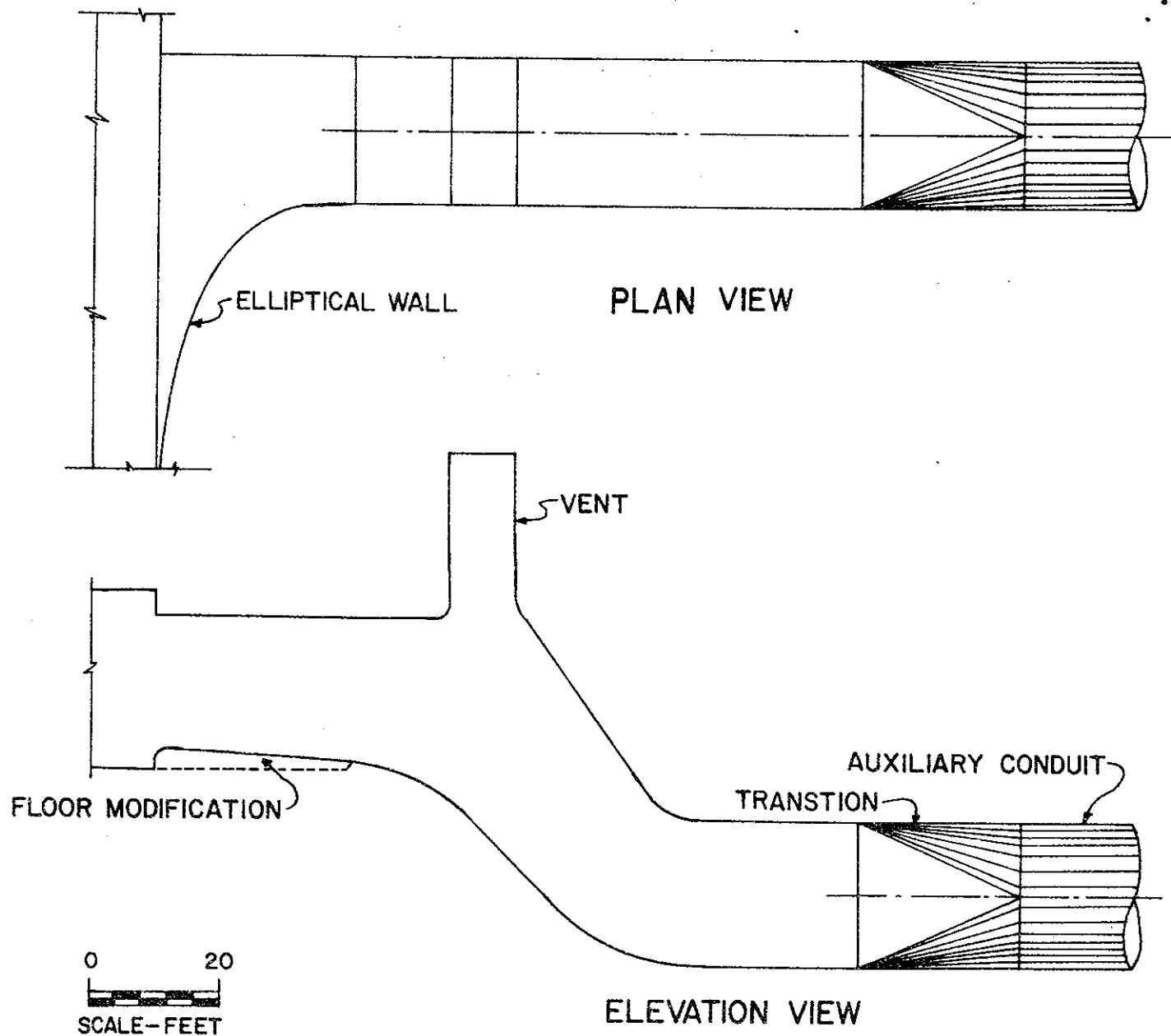


FIGURE NO. 4

DROP STRUCTURE
PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY.

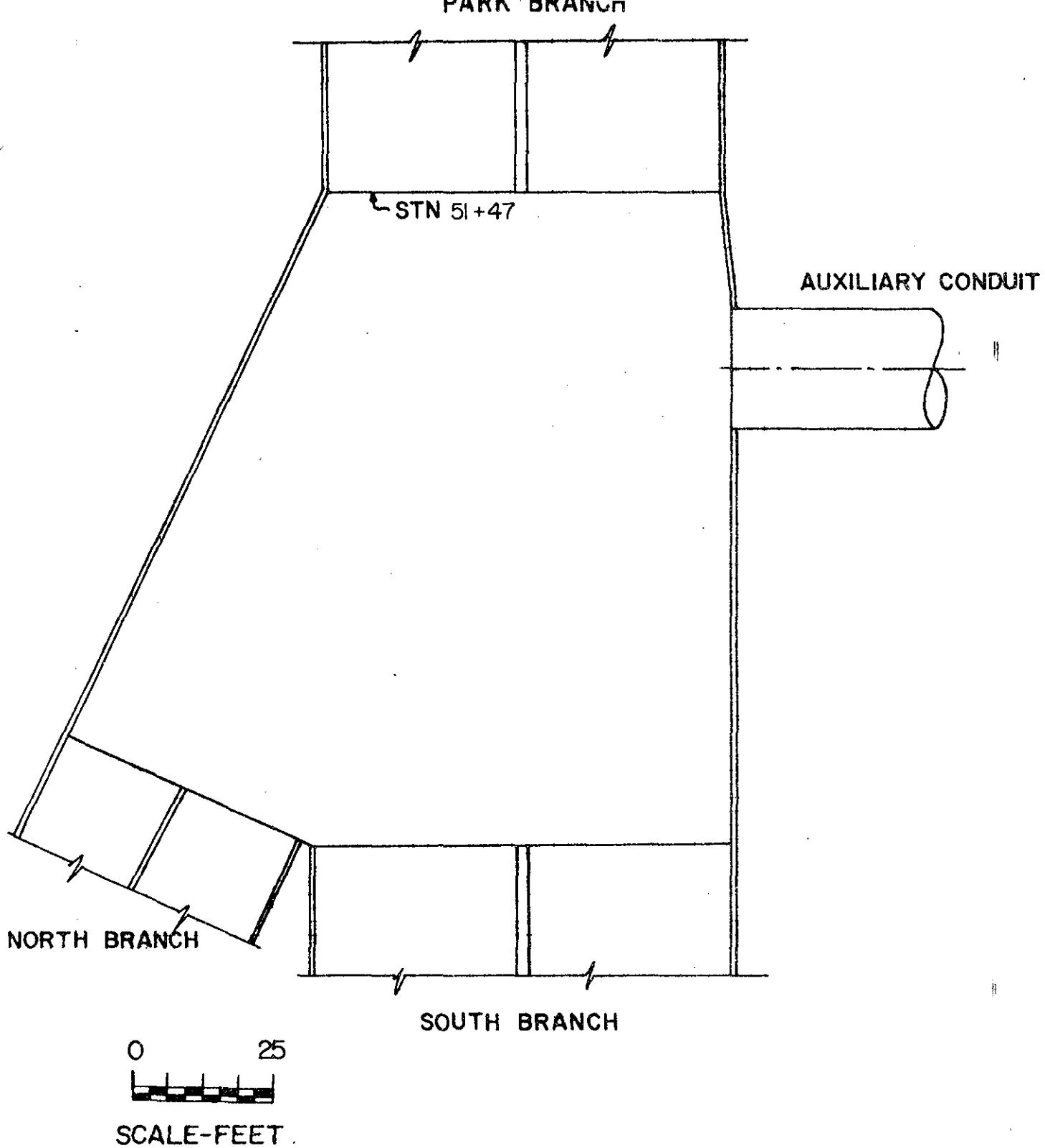


FIGURE NO. 5

ORIGINAL AUXILIARY ENTRANCE
PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY

ARL

NORTH
BRANCH

SOUTH
BRANCH

PARK
BRANCH

STN 51+47

ELLIPTICAL WALL

TRANSITION

AUXILIARY CONDUIT

0 25
SCALE - FEET

FIGURE NO. 6

ELLIPTICAL AUXILIARY ENTRANCE
PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY

ARL

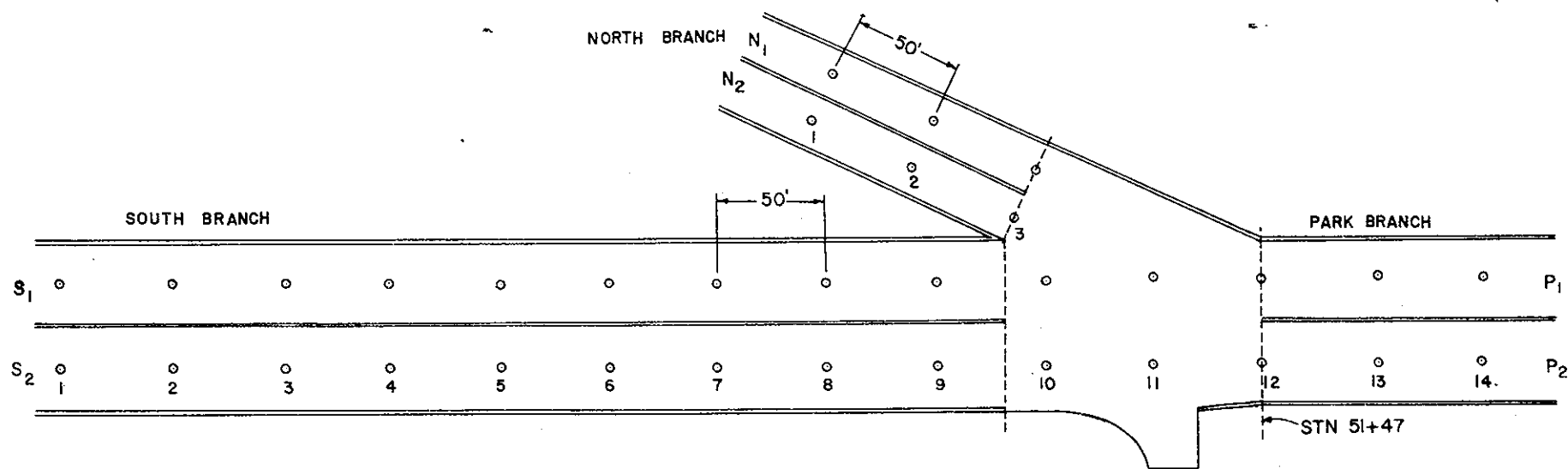


FIGURE NO. 7

LOCATION OF PIEZOMETERS
PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY

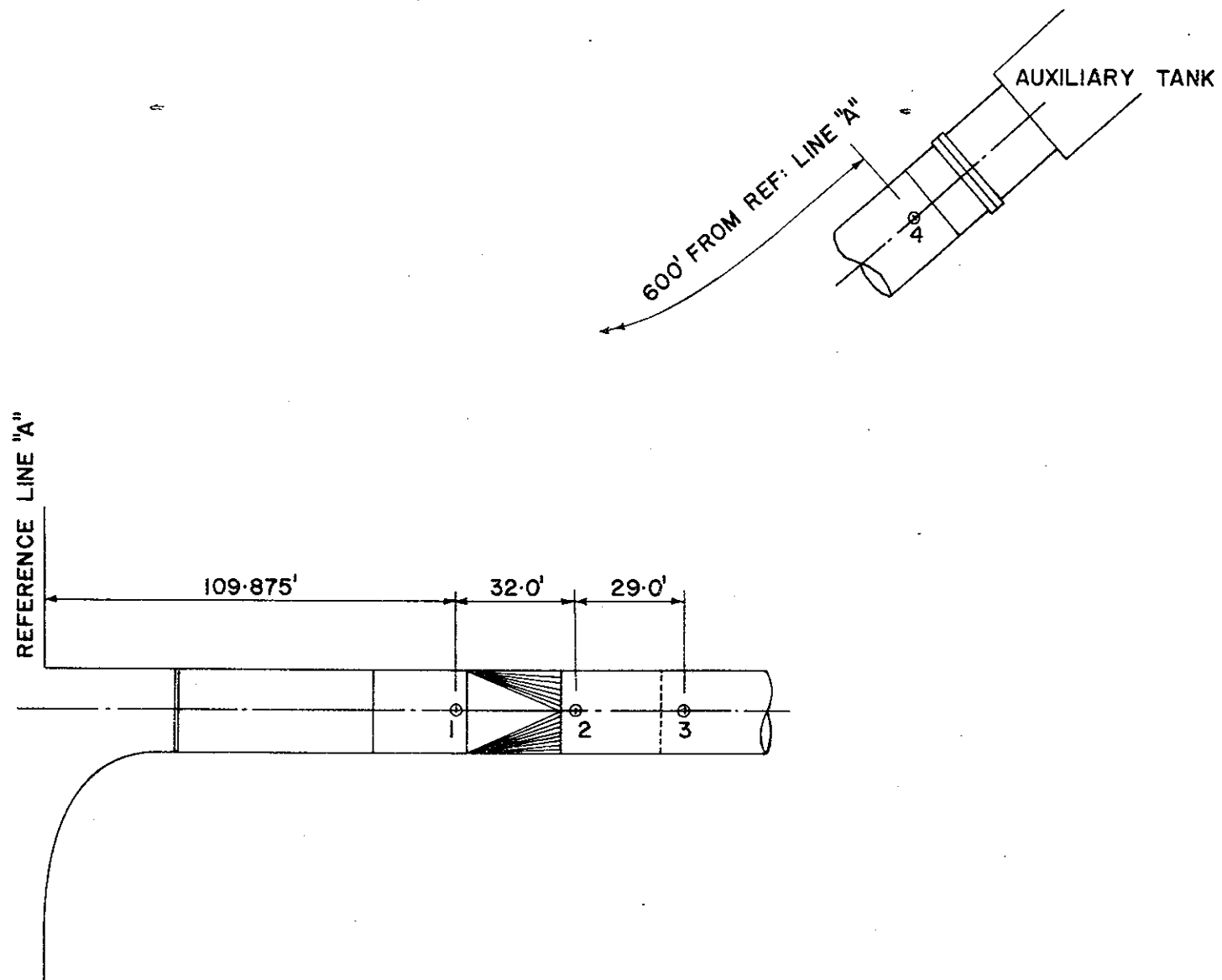


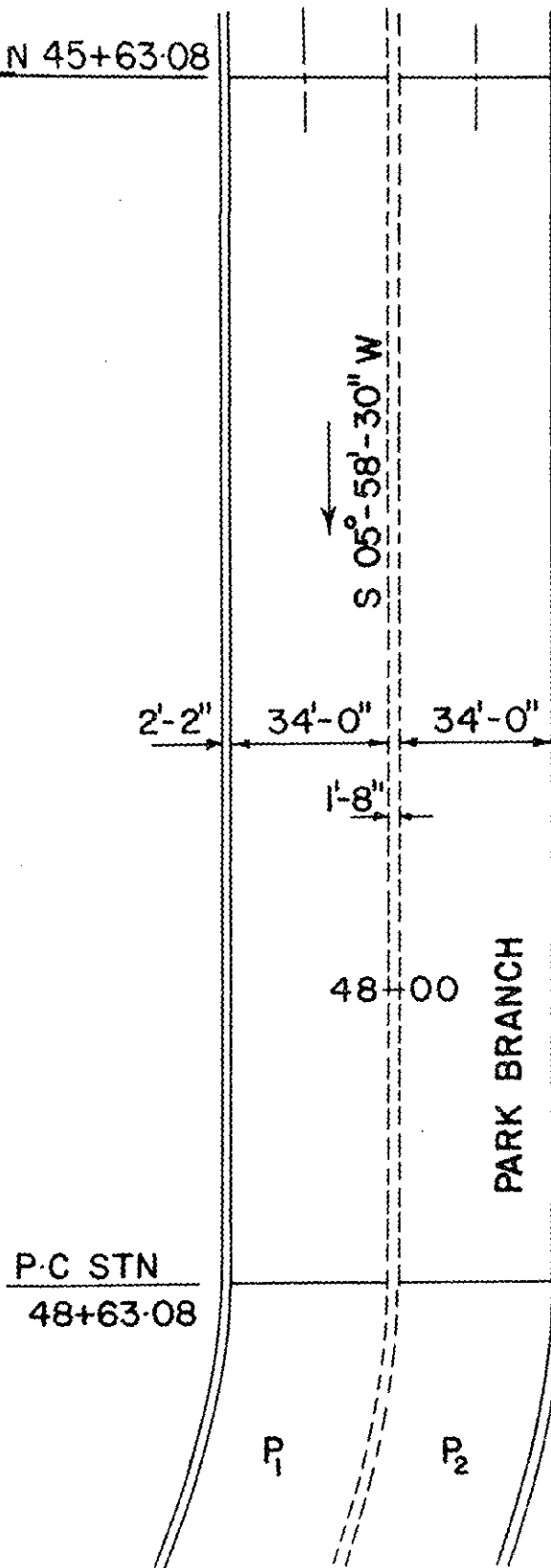
FIGURE NO. 8

LOCATION OF AUXILIARY CONDUIT PIEZOMETERS
 PARK RIVER CONDUIT JUNCTION STRUCTURE
 MODEL STUDY

STN 45+63.08

REFERENCE POINTS

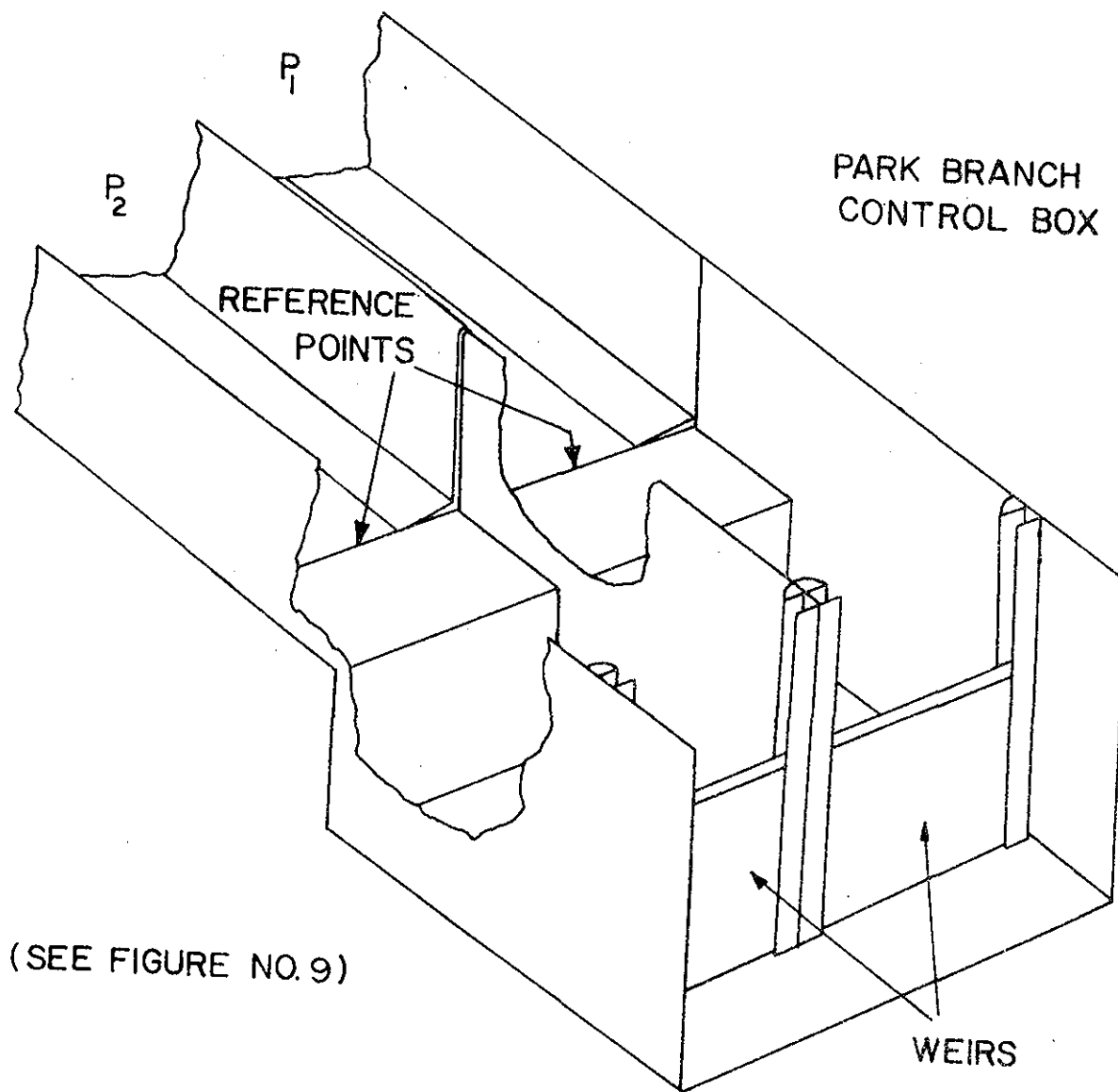
(SEE FIGURE NO. 10)



REFERENCE POINT LOCATION
PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY

FIGURE NO. 9

ARL



REFERENCE POINT LOCATION
PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY

FIGURE NO. 10

D A T A

TEST NO. 115

POINT	Y_1 MODEL FT.	Y_1 PROTO. FT.	Y_2 MODEL FT.	Y_2 PROTO. FT.
S- 1	0.660	16.500	0.648	16.200
2	0.670	16.750	0.645	16.125
3	0.675	16.875	0.660	16.500
4	0.690	17.250	0.660	16.500
5	0.690	17.250	0.664	16.600
6	0.705	17.625	0.665	16.625
7	0.708	17.700	0.682	17.050
8	0.720	18.000	0.690	17.250
9	0.718	17.950	0.683	17.075
10	0.740	18.500	0.712	17.800
11	0.760	19.000	0.725	18.125
P - 12	0.700	17.500	0.722	18.050
13	0.725	18.125	0.715	17.875
14	0.715	17.875	0.720	18.000
REF. POINT	0.703	17.570	0.722	18.050
N- 1	0.670	16.750	0.700	17.500
2	0.680	17.000	0.700	17.500
3	0.703	17.575	0.710	17.75
POINT	MODEL FT		PROTOTYPE FT	
A- 1				
2				
3				
4				

DATE 2/26/74OBSERVER P.J. ARK

PARK BRANCH WEIR LEVEL = + 3.15'

AUXILIARY CONDUIT WEIR LEVEL = - 12.075

 $Q_{\text{SOUTH}} = 12630 \text{ CFS}$ $Q_{\text{NORTH}} = 6470 \text{ CFS}$ $Q_{\text{PARK}} = 13350 \text{ CFS}$ $Q_{\text{AUXILIARY}} = 5750 \text{ CFS}$

COMMENTS:

Y = HYDRAULIC DEPTH

South - North flowrate ratio is 2:1

HYDRAULIC GRADIENT DATA
PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY

ARL

TEST NO. 117

POINT	Y ₁ MODEL FT.	Y ₁ PROTO. FT.	Y ₂ MODEL FT.	Y ₂ PROTO. FT.
S- 1	0.675	16.875	0.680	17.000
2	0.665	16.625	0.680	17.000
3	0.690	17.250	0.692	17.300
4	0.712	17.800	0.698	17.450
5	0.712	17.800	0.700	17.500
6	0.723	18.075	0.702	17.550
7	0.728	18.200	0.720	18.000
8	0.740	18.500	0.730	18.250
9	0.738	18.450	0.718	17.950
10	0.758	18.950	0.748	18.700
11	0.780	19.500	0.770	19.250
P - 12	0.709	17.725	0.716	17.900
13	0.730	18.250	0.713	17.825
14	0.660	16.500	0.730	18.250
REF. POINT	.699	17.470	0.706	17.65
N- 1	0.700	17.500	0.718	17.950
2	0.702	17.550	0.718	17.950
3	0.718	17.950	0.728	18.200
POINT	MODEL FT		PROTOTYPE FT	
A- 1				
2				
3				
4				

DATE 2/27/74OBSERVER RJ ARK

PARK BRANCH WEIR LEVEL = +3.15'

AUXILIARY CONDUIT WEIR LEVEL = _____

Q_{SOUTH} = 9994 CFSQ_{NORTH} = 4040 CFSQ_{PARK} = 14000 CFSQ_{AUXILIARY} = _____

COMMENTS:

Y = HYDRAULIC DEPTH

Auxiliary Conduit Blocked at end of ellipse.

HYDRAULIC GRADIENT DATA

PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY

ARL

TEST NO. 119

POINT	Y_1 MODEL FT.	Y_1 PROTO. FT.	Y_2 MODEL FT.	Y_2 PROTO. FT.
S- 1	1.292	32.300	1.299	32.475
2	1.298	32.450	1.301	32.525
3	1.306	32.650	1.318	32.950
4	1.325	33.125	1.308	32.700
5	1.312	32.800	1.309	32.725
6	1.320	33.000	1.318	32.950
7	1.328	33.125	1.330	33.250
8	1.335	33.375	1.340	33.500
9	1.330	33.250	1.330	33.250
10	1.350	33.750	1.358	33.950
11	1.380	34.500	1.378	34.450
P - 12	1.320	33.000	1.342	33.550
13	1.338	33.450	1.344	33.600
14	1.330	33.250	1.350	33.750
REF. POINT	—	—	—	—
N- 1	1.292	32.300	1.314	32.850
2	1.301	32.525	1.312	32.800
3	1.320	33.000	1.326	33.15
POINT	MODEL FT		PROTOTYPE FT	
A- 1				
2				
3				
4				

DATE 3/5/74OBSERVER GJ. QAK

PARK BRANCH WEIR LEVEL = + 15.15'

AUXILIARY CONDUIT WEIR LEVEL = —

 $Q_{\text{SOUTH}} = 12014 \text{ CFS}$ $Q_{\text{NORTH}} = 6065 \text{ CFS}$ $Q_{\text{PARK}} = 18079 \text{ CFS}$ $Q_{\text{AUXILIARY}} = \text{—}$

COMMENTS:

Y = HYDRAULIC DEPTH

Auxiliary Conduit blocked at end of ellipse.
Depth of water @ reference point could not
be measured due to limits on point gauges

HYDRAULIC GRADIENT DATA

PARK RIVER CONDUIT JUNCTION STRUCTURE.
MODEL STUDY

ARL

TEST NO. 124DATE 3/19/74OBSERVER G.J. AMH

POINT	Y ₁ MODEL FT.	Y ₁ PROTO. FT.	Y ₂ MODEL FT.	Y ₂ PROTO. FT.
S- 1	0.810	20.25	0.788	19.70
2	0.822	20.55	0.793	19.825
3	0.825	20.625	0.805	20.125
4	0.850	21.250	0.803	20.075
5	0.845	21.125	0.808	20.20
6	0.860	21.50	0.815	20.375
7	0.865	21.625	0.830	20.75
8	0.875	21.875	0.840	21.00
9	0.880	22.00	0.825	20.625
10	0.895	22.375	0.858	21.450
11	0.910	22.75	0.868	21.70
12	0.845	21.125	0.88	22.00
13	0.880	22.00	0.872	21.80
14	0.865	21.625	0.870	21.75
REF. POINT	0.845	21.16	0.856	21.40
N- 1	0.830	20.75	0.860	21.50
2	0.835	20.875	0.855	21.375
3	0.858	21.45	0.870	21.75
POINT	MODEL FT		PROTOTYPE FT	
A- 1	1.59	±0.05	39.75	
2	1.51	±0.02	37.75	
3	1.55	±0.01	38.75	
4	1.50		37.50	

PARK BRANCH WEIR LEVEL = *MINIMUM*AUXILIARY CONDUIT WEIR LEVEL = *MINIMUM*Q_{SOUTH} = 17322 CFSQ_{NORTH} = 7690 CFSQ_{PARK} = 17968 CFSQ_{AUXILIARY} = 7032

COMMENTS:

Y = HYDRAULIC DEPTH

HYDRAULIC GRADIENT DATA
PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY

ARL

TEST NO. 125

POINT	Y ₁ MODEL FT.	Y ₁ PROTO. FT.	Y ₂ MODEL FT.	Y ₂ PROTO. FT.
S- 1	0.831	20.775	0.801	20.025
2	0.831	20.775	0.805	20.125
3	0.840	21.00	0.820	20.50
4	0.865	21.625	0.818	20.45
5	0.865	21.625	0.826	20.65
6	0.872	21.800	0.832	20.80
7	0.880	22.00	0.846	21.15
8	0.892	22.30	0.855	21.375
9	0.890	22.25	0.848	21.20
10	0.914	22.85	0.870	21.75
11	0.925	23.125	0.898	22.45
P - 12	0.850	21.25	0.895	22.375
13	0.890	22.25	0.888	22.20
14	0.870	21.75	0.888	22.20
REF. POINT	0.860	21.50	0.867	21.675
N- 1	0.845	21.125	0.881	22.025
2	0.850	21.25	0.870	21.75
3	0.870	21.75	0.885	22.125
POINT	MODEL FT		PROTOTYPE FT	
A- 1	1.955 ± 0.05		48.875	
2	1.835 ± 0.05		45.875	
3	1.840 ± 0.05		46.00	
4	1.770 ± 0.01		44.25	

DATE 3/19/74OBSERVER GJ AHH

PARK BRANCH WEIR LEVEL = MINIMUM

AUXILIARY CONDUIT WEIR LEVEL = INTERMEDIATE

Q_{SOUTH} = 17322 CFSQ_{NORTH} = 7690 CFSQ_{PARK} = 18230 CFSQ_{AUXILIARY} = 6770 CFS

COMMENTS:

Y = HYDRAULIC DEPTH

HYDRAULIC GRADIENT DATA

PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY

ARL

TEST NO. 126

POINT	Y ₁ MODEL FT.	Y ₁ PROTO. FT.	Y ₂ MODEL FT.	Y ₂ PROTO. FT.
S- 1	0.890	22.25	0.868	21.70
2	0.894	22.35	0.870	21.75
3	0.900	22.50	0.882	22.05
4	0.904	22.60	0.882	22.05
5	0.895	22.375	0.883	22.075
6	0.916	22.90	0.890	22.25
7	0.920	23.00	0.894	22.35
8	0.938	23.45	0.900	22.50
9	0.940	23.50	0.895	22.375
10	0.955	23.875	0.925	23.125
11	0.975	24.375	0.945	23.625
P-12	0.890	22.25	0.925	23.125
13	0.920	23.00	0.915	22.875
14	0.905	22.625	0.914	22.85
REF. POINT	0.894	22.35	0.900	22.50
N- 1	0.890	22.25	0.910	22.75
2	0.895	22.375	0.912	22.80
3	0.915	22.875	0.925	23.125
POINT	MODEL FT		PROTOTYPE FT	
A- 1	2.085		52.125	
2	2.00		50.00	
3	1.995		49.875	
4	1.948		48.70	

DATE 3/19/74OBSERVER PJ. ORR

PARK BRANCH WEIR LEVEL = MINIMUM

AUXILIARY CONDUIT WEIR LEVEL = MAXIMUM

 $Q_{\text{SOUTH}} = 17322$ $Q_{\text{NORTH}} = 7690$ $Q_{\text{PARK}} = 19683$ $Q_{\text{AUXILIARY}} = 5317$

COMMENTS:

Y = HYDRAULIC DEPTH

HYDRAULIC GRADIENT DATA

PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY

ARL

TEST NO. 127

POINT	Y ₁ MODEL FT.	Y ₁ PROTO. FT.	Y ₂ MODEL FT.	Y ₂ PROTO. FT.
S- 1	0.998	24.95	0.980	24.50
2	1.005	25.125	0.980	24.50
3	1.019	25.475	1.000	25.00
4	1.032	25.80	0.996	24.90
5	1.016	25.40	1.000	25.00
6	1.026	25.65	1.011	25.275
7	1.029	25.725	1.020	25.50
8	1.045	26.125	1.032	25.80
9	1.040	26.00	1.016	25.40
10	1.068	26.70	1.052	26.30
11	1.090	27.25	1.059	26.475
P - 12	1.052	26.30	1.078	26.95
13	1.072	26.80	1.070	26.75
14	1.068	26.70	1.082	27.05
REF. POINT	1.077	26.93	1.088	27.20
N- 1	1.010	25.25	1.035	25.875
2	1.020	25.50	1.030	25.75
3	1.038	25.95	1.044	26.10
POINT	MODEL FT		PROTOTYPE FT	
A- 1	1.960	±0.01	49.00	
2	1.775	±0.005	44.375	
3	1.770	±0.005	44.25	
4	1.650	±0.01	41.25	

DATE 3/19/74OBSERVER RJ. AHHPARK BRANCH WEIR LEVEL = *INTERMEDIATE*AUXILIARY CONDUIT WEIR LEVEL = *MINIMUM*Q_{SOUTH} = 17322 CFSQ_{NORTH} = 7690 CFSQ_{PARK} = 16306 CFSQ_{AUXILIARY} = 8694 CFS

COMMENTS:

Y = HYDRAULIC DEPTH

HYDRAULIC GRADIENT DATA

PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY

ARL

TEST NO. 128

POINT	Y ₁ MODEL FT.	Y ₁ PROTO. FT.	Y ₂ MODEL FT.	Y ₂ PROTO. FT.
S- 1	1.028	25.70	1.018	25.45
2	1.042	26.05	1.020	25.50
3	1.048	26.20	1.032	25.80
4	1.065	26.625	1.031	25.775
5	1.050	26.25	1.032	25.80
6	1.065	26.625	1.042	26.05
7	1.066	26.65	1.053	26.325
8	1.078	26.95	1.062	26.55
9	1.08	27.00	1.054	26.35
10	1.098	27.45	1.081	27.025
11	1.125	28.125	1.092	27.30
P - 12	1.075	26.875	1.100	27.50
13	1.100	27.50	1.096	27.40
14	1.092	27.30	1.104	27.60
REF. POINT	1.106	27.65	1.115	27.86
N- 1	1.040	26.00	1.065	26.625
2	1.050	26.25	1.064	26.60
3	1.070	26.75	1.075	26.875
POINT	MODEL FT		PROTOTYPE FT	
A- 1	2.12		53.00	
2	1.975 ± 0.005		49.375	
3	1.96 ± 0.005		49.00	
4	1.8 ± 0.01		46.50	

DATE 3/19/74OBSERVER GJ OAKPARK BRANCH WEIR LEVEL = *INTERMEDIATE*AUXILIARY CONDUIT WEIR LEVEL = *INTERMEDIATE*Q_{SOUTH} = 17322 CFSQ_{NORTH} = 7690 CFSQ_{PARK} = 17212 CFSQ_{AUXILIARY} = 7788 CFS

COMMENTS:

Y = HYDRAULIC DEPTH

HYDRAULIC GRADIENT DATA

PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY

ARL

TEST NO. 129DATE 3/19/74OBSERVER RJ OHA

POINT	Y ₁ MODEL FT.	Y ₁ PROTO. FT.	Y ₂ MODEL FT.	Y ₂ PROTO. FT.
S- 1	1.086	27.15	1.080	27.00
2	1.095	27.375	1.081	27.025
3	1.108	27.70	1.097	27.425
4	1.121	28.025	1.093	27.325
5	1.104	27.60	1.096	27.40
6	1.118	27.95	1.109	27.725
7	1.122	28.05	1.113	27.825
8	1.130	28.25	1.128	28.20
9	1.129	28.225	1.110	27.75
10	1.149	28.725	1.141	28.525
11	1.168	29.20	1.155	28.875
P - 12	1.113	27.825	1.150	28.75
13	1.140	28.50	1.140	28.50
14	1.136	28.40	1.148	28.70
REF. POINT	1.147	28.68	1.154	28.85
N- 1	1.090	27.25	1.118	27.95
2	1.100	27.50	1.105	27.625
3	1.115	27.875	1.122	28.05
POINT	MODEL FT		PROTOTYPE FT	
A- 1	2.240		56.0	
2	2.130		53.25	
3	2.115		52.88	
4	2.06 ± 0.005		51.50	

PARK BRANCH WEIR LEVEL = INTERMEDIATE

AUXILIARY CONDUIT WEIR LEVEL = MAXIMUM

 $Q_{\text{SOUTH}} = 17322 \text{ CFS}$ $Q_{\text{NORTH}} = 7690 \text{ CFS}$ $Q_{\text{PARK}} = 18591 \text{ CFS}$ $Q_{\text{AUXILIARY}} = 6409 \text{ CFS}$

COMMENTS:

Y = HYDRAULIC DEPTH

HYDRAULIC GRADIENT DATA

PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY

ARL

TEST NO. 130DATE 3/20/74OBSERVER RJ. UAK

POINT	Y ₁ MODEL FT.	Y ₁ PROTO. FT.	Y ₂ MODEL FT.	Y ₂ PROTO. FT.
S- 1	1.190	29.75	1.180	29.50
2	1.198	29.95	1.178	29.45
3	1.202	30.05	1.188	29.70
4	1.222	30.55	1.188	29.70
5	1.210	30.25	1.192	29.80
6	1.224	30.60	1.199	29.975
7	1.225	30.625	1.210	30.25
8	1.238	30.95	1.216	30.40
9	1.235	30.875	1.205	30.125
10	1.255	31.375	1.232	30.80
11	1.285	32.125	1.244	31.10
P - 12	1.250	31.250	1.272	31.80
13	1.266	31.650	1.258	31.45
14	1.262	31.55	1.272	31.80
REF. POINT	1.272	31.80	1.277	31.93
N- 1	1.192	29.80	1.225	30.625
2	1.195	29.875	1.212	30.30
3	1.215	30.375	1.227	30.675
POINT	MODEL FT		PROTOTYPE FT	
A- 1	2.155		53.875	
2	1.940 ± 0.01		48.50	
3	1.925 ± 0.01		48.125	
4	1.77 ± 0.01		44.50	

PARK BRANCH WEIR LEVEL = MAXIMUM

AUXILIARY CONDUIT WEIR LEVEL = MINIMUM

Q_{SOUTH} = 17322 CFSQ_{NORTH} = 7690 CFSQ_{PARK} = 15530 CFSQ_{AUXILIARY} = 9470 CFS

COMMENTS:

Y = HYDRAULIC DEPTH

HYDRAULIC GRADIENT DATA

PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY

APRIL

TEST NO. 131

POINT	Y ₁ MODEL FT.	Y ₁ PROTO. FT.	Y ₂ MODEL FT.	Y ₂ PROTO. FT.
S- 1	1.218	30.45	1.215	30.375
2	1.232	30.80	1.215	30.375
3	1.248	31.20	1.232	30.80
4	1.260	31.50	1.226	30.65
5	1.247	31.175	1.230	30.75
6	1.258	31.45	1.243	31.075
7	1.258	31.45	1.246	31.15
8	1.276	31.90	1.262	31.55
9	1.270	31.75	1.242	31.05
10	1.290	32.25	1.279	31.975
11	1.320	33.00	1.289	32.225
P - 12	1.277	31.925	1.308	32.70
13	1.290	32.25	1.296	32.40
14	1.286	32.15	1.304	32.60
REF. POINT	1.292	32.30	1.302	32.55
N- 1	1.220	30.50	1.250	31.25
2	1.240	31.00	1.255	31.375
3	1.250	31.25	1.265	31.625
POINT	MODEL FT		PROTOTYPE FT	
A- 1	2.255	± 0.005	56.375	
2	2.075	± 0.01	51.875	
3	2.065	± 0.005	51.625	
4	1.96	± 0.01	49.00	

DATE 3/20/74OBSERVER R. OAK

PARK BRANCH WEIR LEVEL = MAXIMUM

AUXILIARY CONDUIT WEIR LEVEL = INTERMEDIATE

 $Q_{\text{SOUTH}} = 17322 \text{ CFS}$ $Q_{\text{NORTH}} = 7690 \text{ CFS}$ $Q_{\text{PARK}} = 16537 \text{ CFS}$ $Q_{\text{AUXILIARY}} = 8463 \text{ CFS}$

COMMENTS:

Y = HYDRAULIC DEPTH

HYDRAULIC GRADIENT DATA

PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY

ARL

TEST NO. 132

POINT	Y ₁ MODEL FT.	Y ₁ PROTO. FT.	Y ₂ MODEL FT.	Y ₂ PROTO. FT.
S- 1	1.260	31.50	1.246	31.15
2	1.274	31.85	1.252	31.30
3	1.276	31.90	1.268	31.70
4	1.295	32.375	1.265	31.625
5	1.280	32.00	1.270	31.75
6	1.292	32.30	1.275	31.875
7	1.290	32.25	1.280	32.00
8	1.305	32.625	1.292	32.30
9	1.303	32.575	1.285	32.125
10	1.328	33.20	1.308	32.70
11	1.344	33.60	1.320	33.00
P - 12	1.300	32.50	1.332	33.20
13	1.320	33.00	1.322	33.05
14	1.310	32.75	1.333	33.325
REF. POINT	1.317	32.925	1.319	32.98
N- 1	1.260	31.50	1.29	32.25
2	1.280	32.00	1.285	32.125
3	1.290	32.25	1.295	32.375
POINT	MODEL FT		PROTOTYPE FT	
A- 1	2.370		59.25	
2	2.23		55.75	
3	2.22		55.50	
4	2.14 ± 0.001		53.50	

DATE 3/20/74

OBSERVER RJ ARR

PARK BRANCH WEIR LEVEL = MAXIMUM

AUXILIARY CONDUIT WEIR LEVEL = MAXIMUM

Q_{SOUTH} = 17322 CFS

Q_{NORTH} = 7690 CFS

Q_{PARK} = 17213 CFS

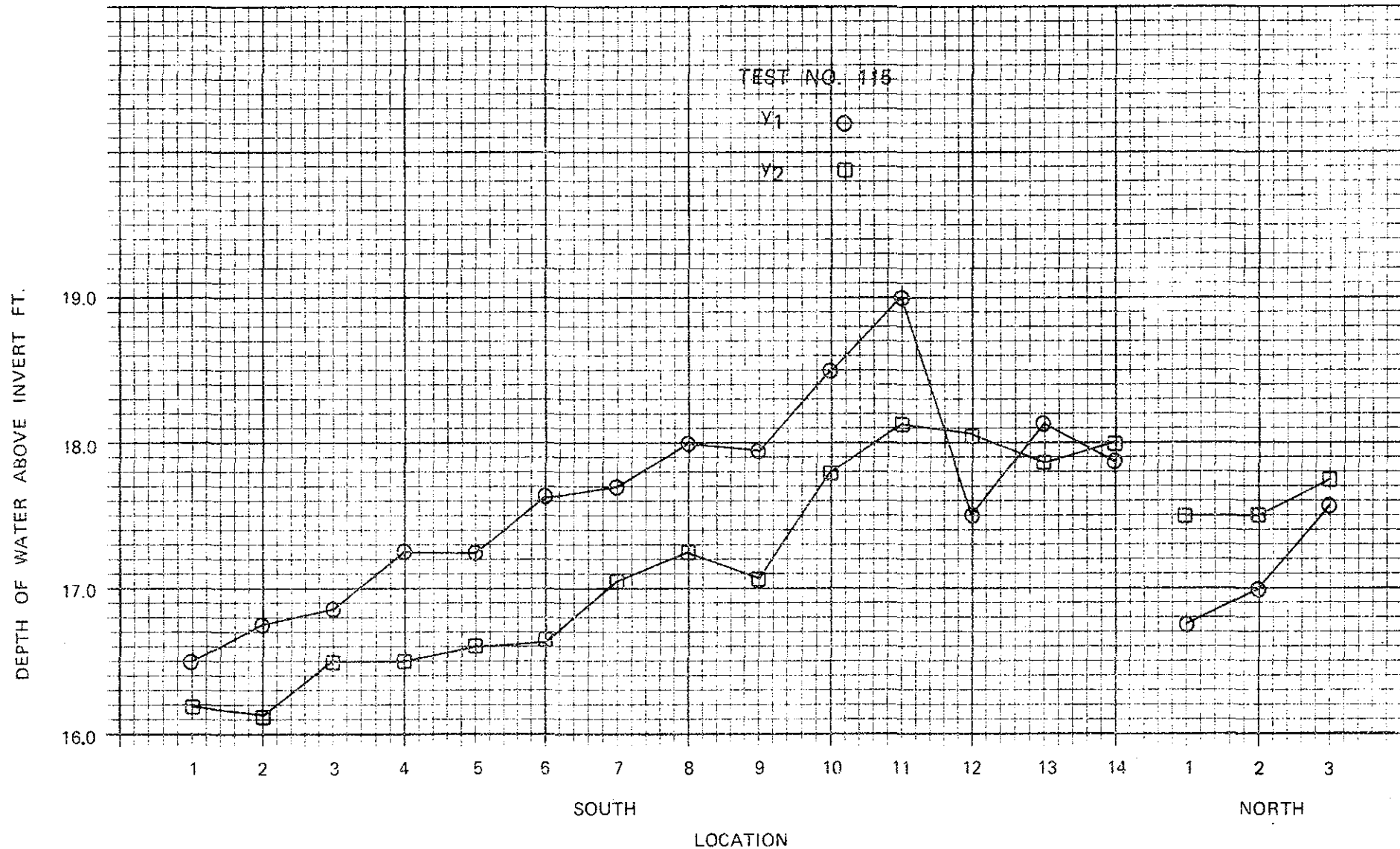
Q_{AUXILIARY} = 7787 CFS

COMMENTS:

Y = HYDRAULIC DEPTH

HYDRAULIC GRADIENT DATA
PARK RIVER CONDUIT JUNCTION STRUCTURE
MODEL STUDY

ARL



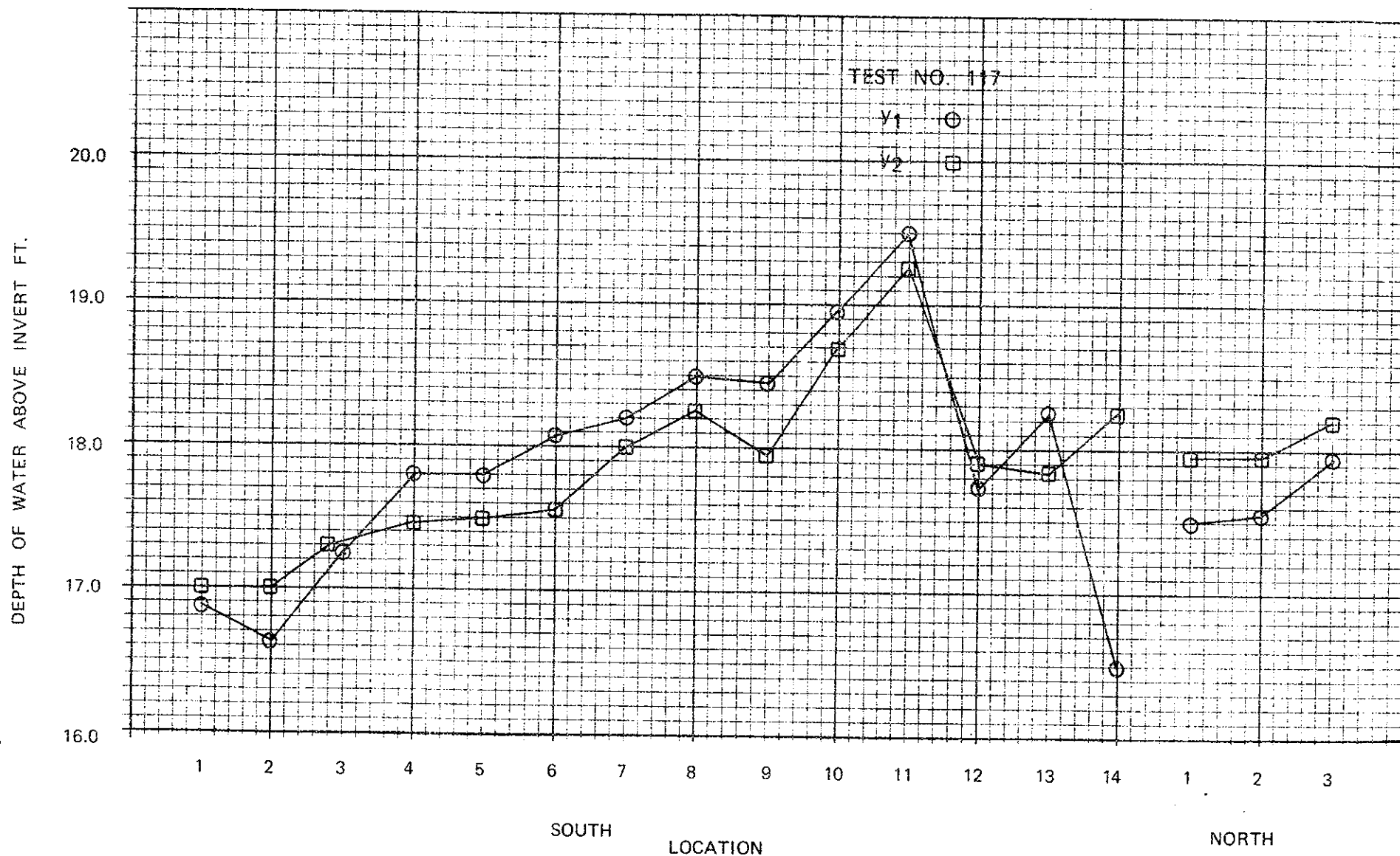
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PARK RIVER CONDUIT JUNCTION STRUCTURE

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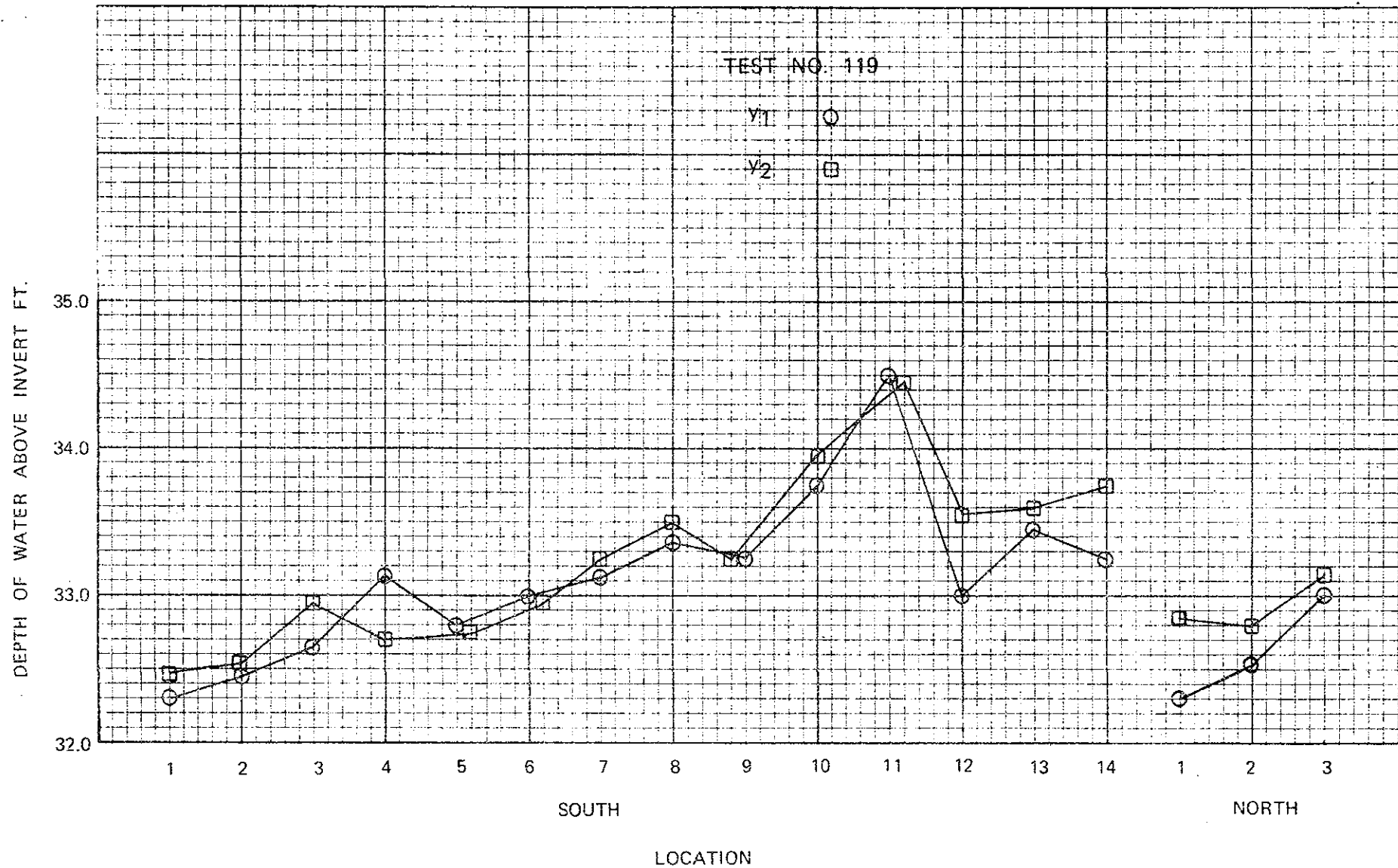
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FEB 27,74



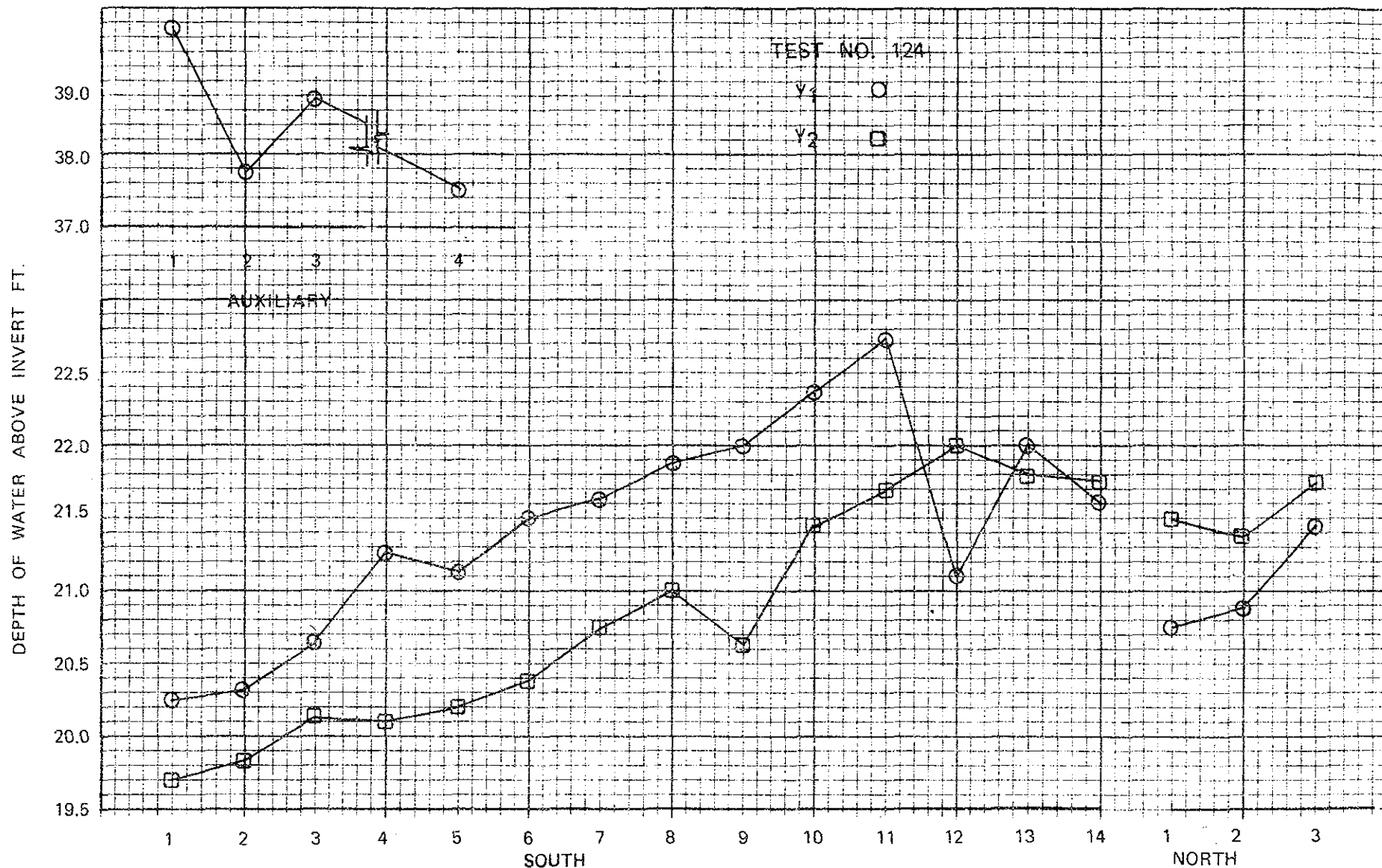
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PARK RIVER CONDUIT JUNCTION STRUCTURE

DEPT. OF ARMY CORPS OF ENGINEERS

MARCH 5, 74



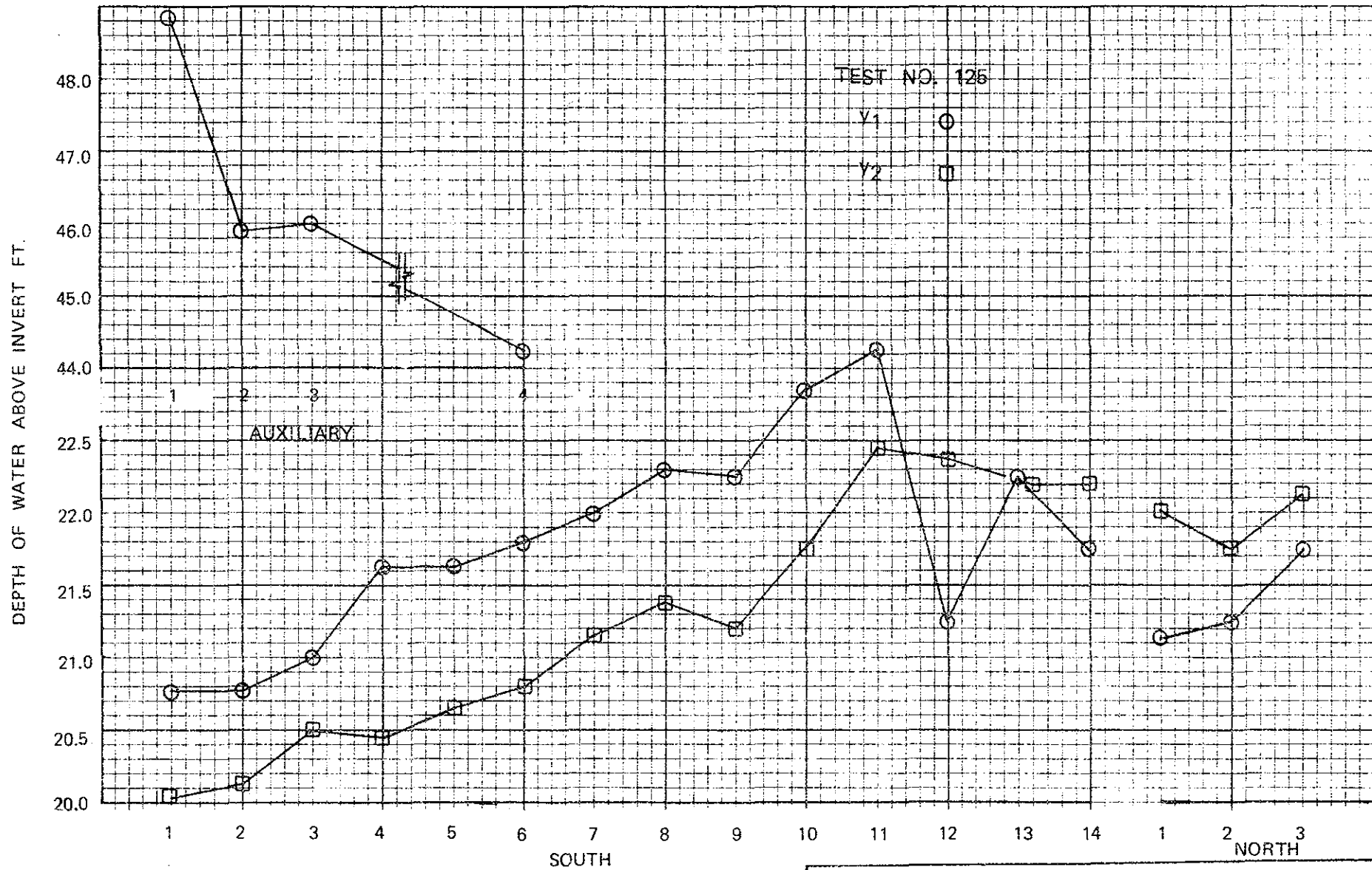
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PARK RIVER CONDUIT JUNCTION STRUCTURE

DEPT. OF ARMY CORPS OF ENGINEERS

MARCH 19,74

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LOCATION

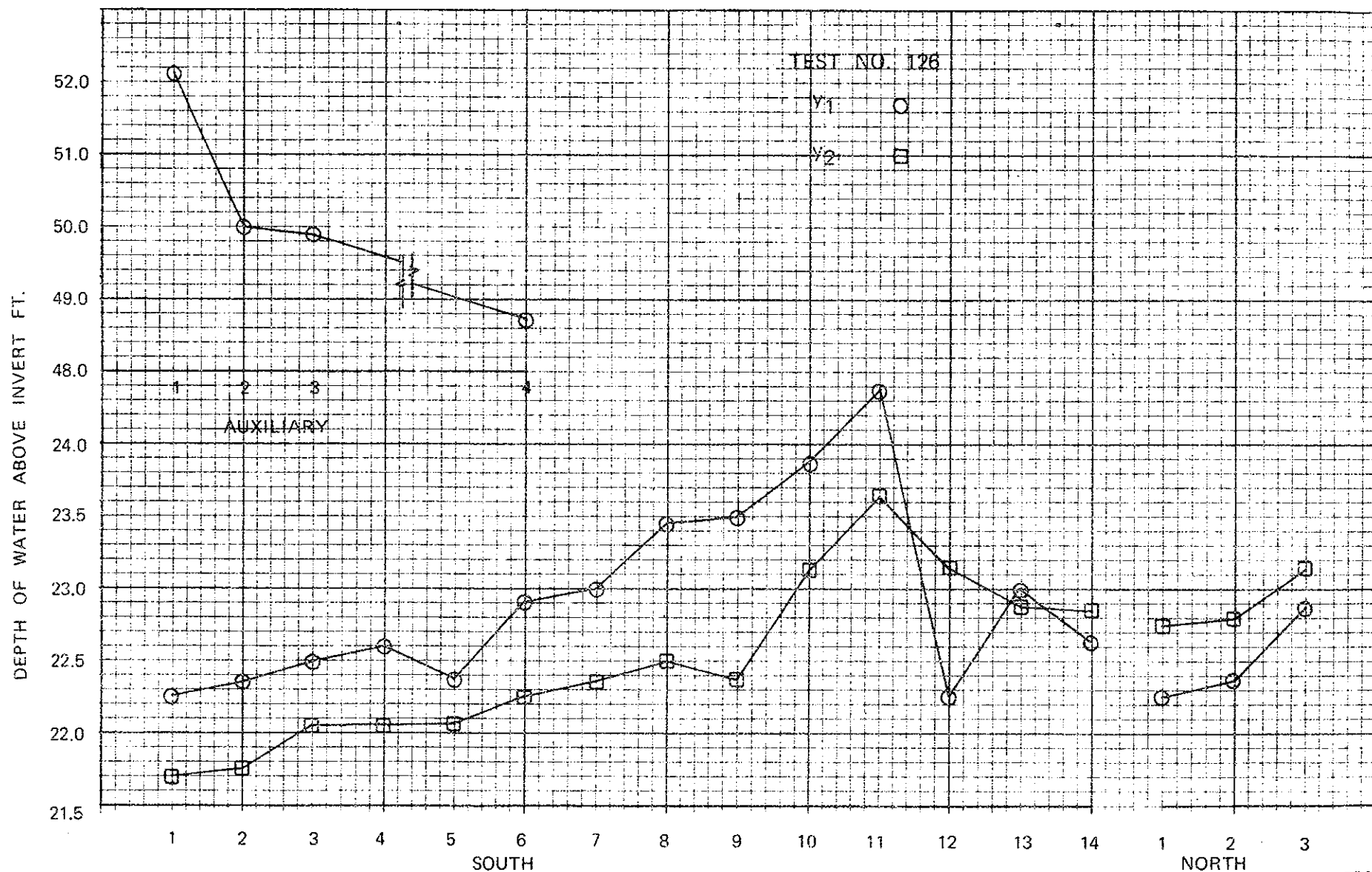
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DEPT. OF ARMY CORPS OF ENGINEERS

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LOCATION

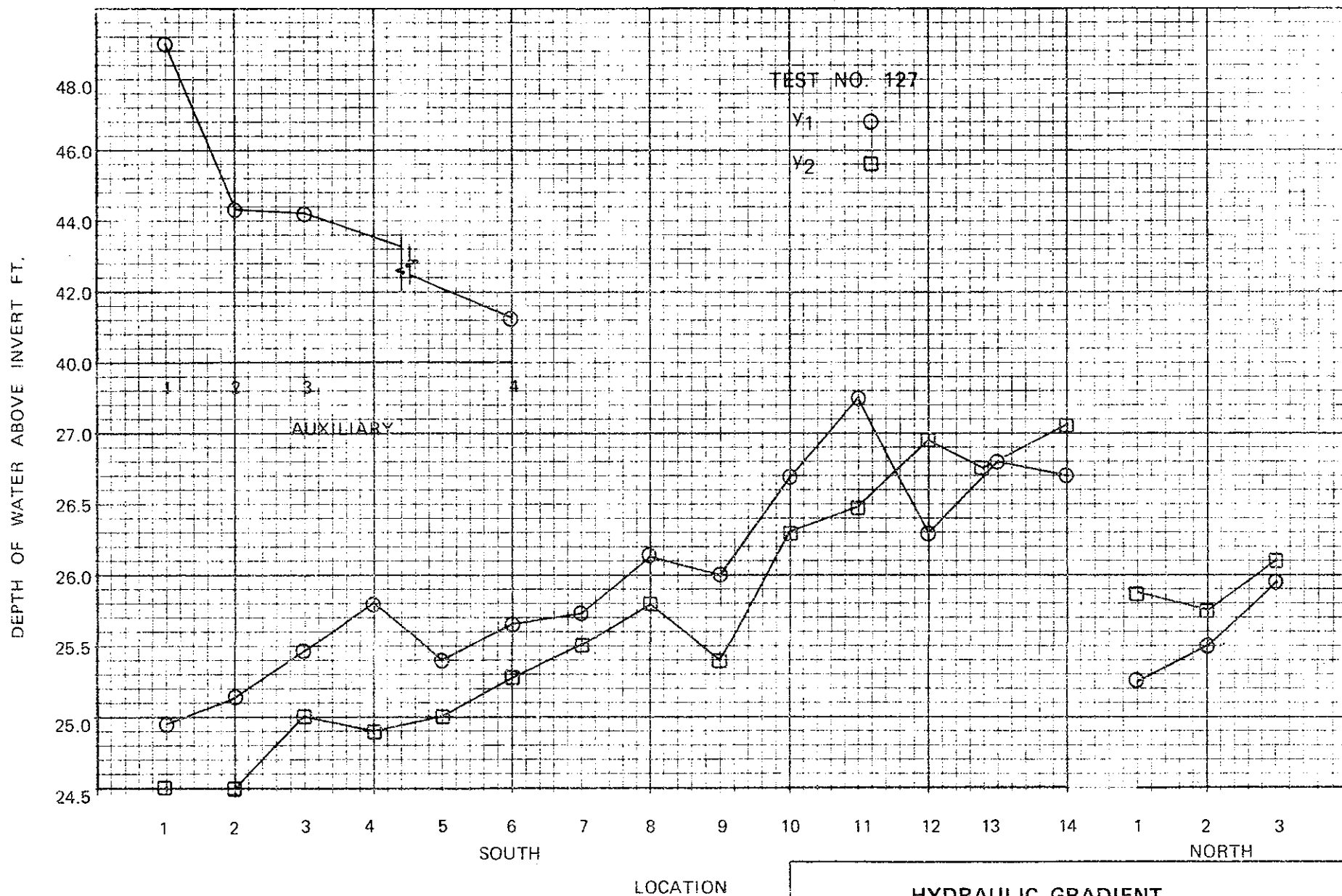
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MARCH 19, 74

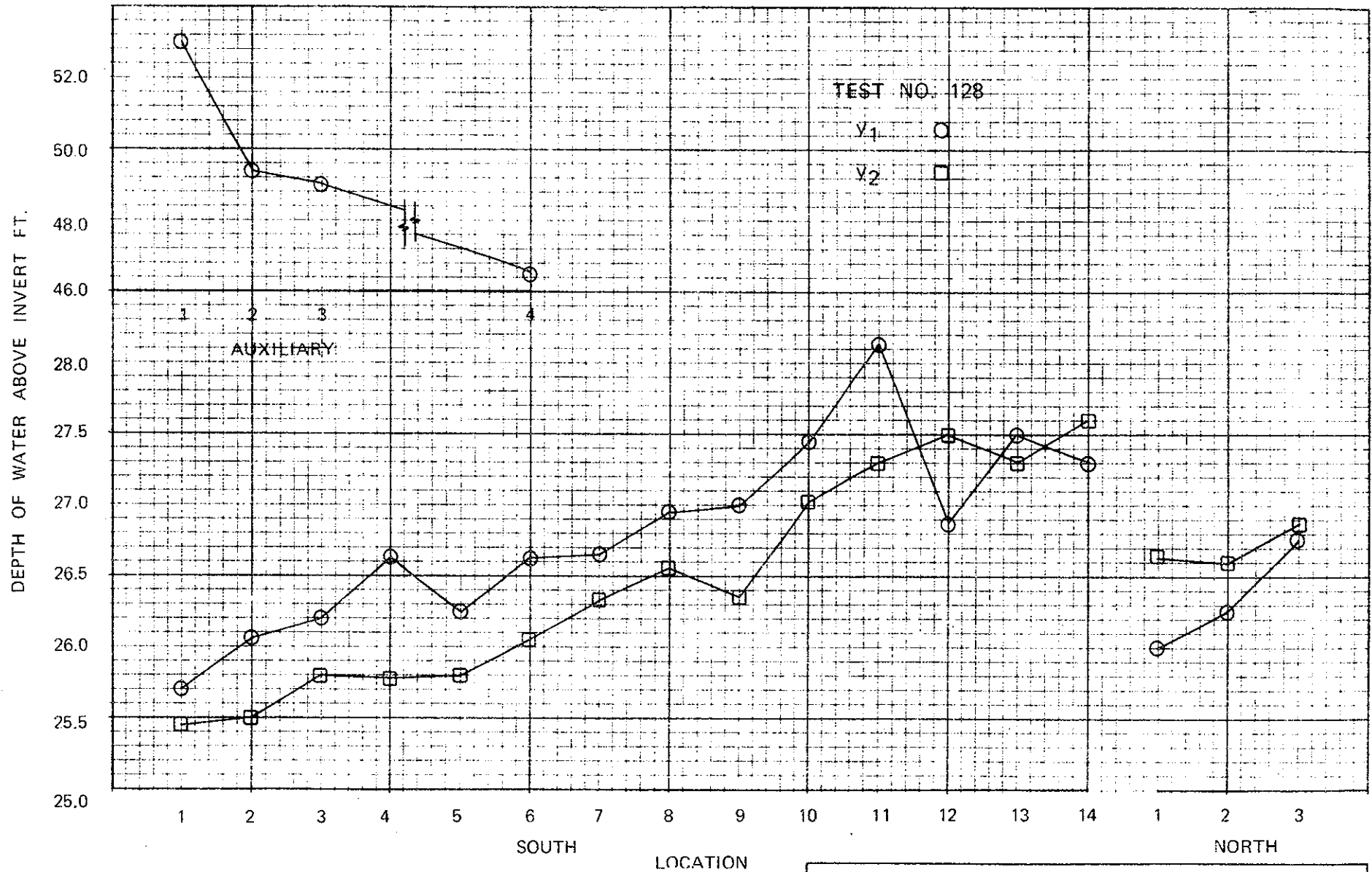
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 DEPT. OF ARMY CORPS OF ENGINEERS
 MARCH 19, 74

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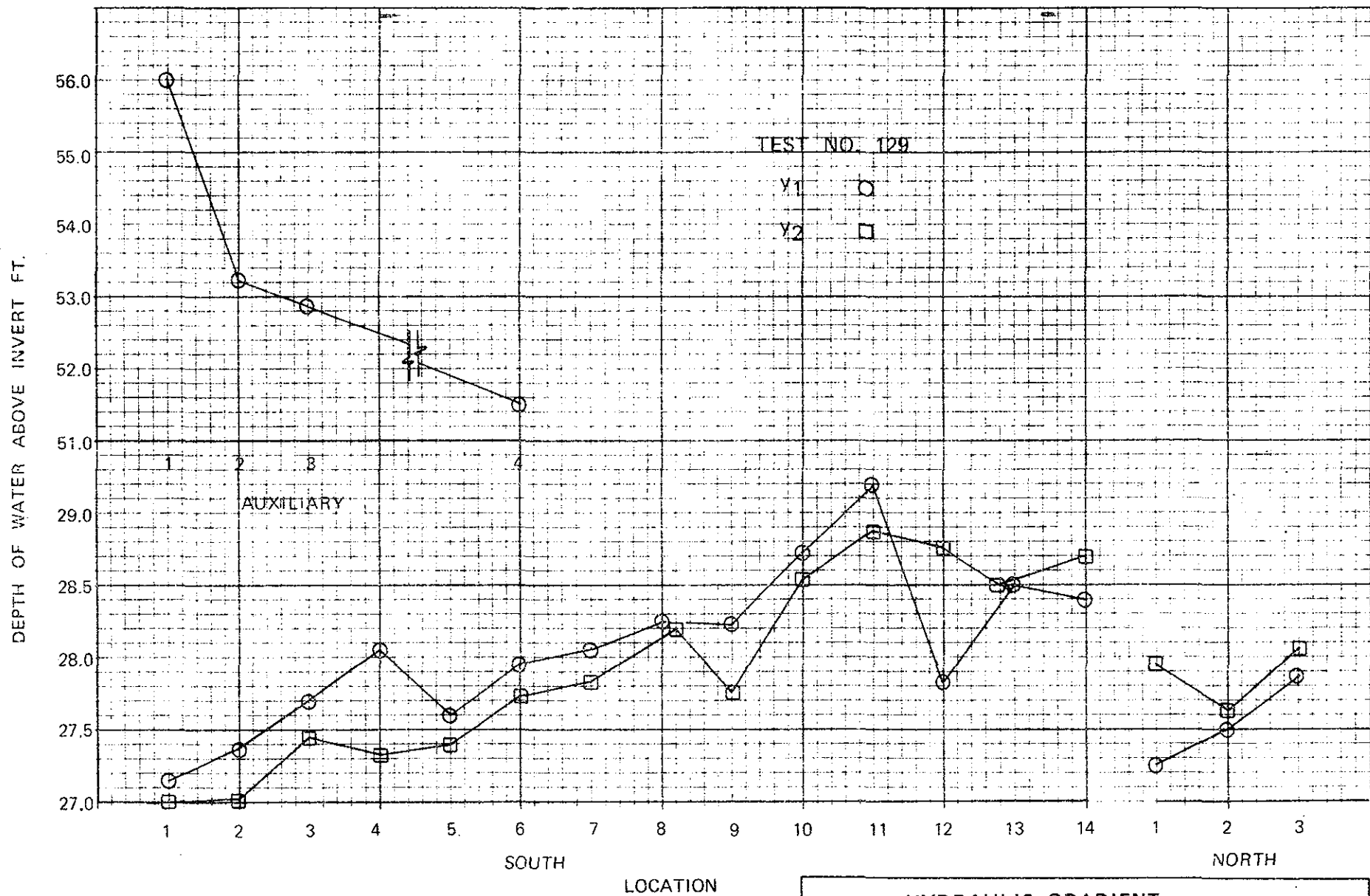
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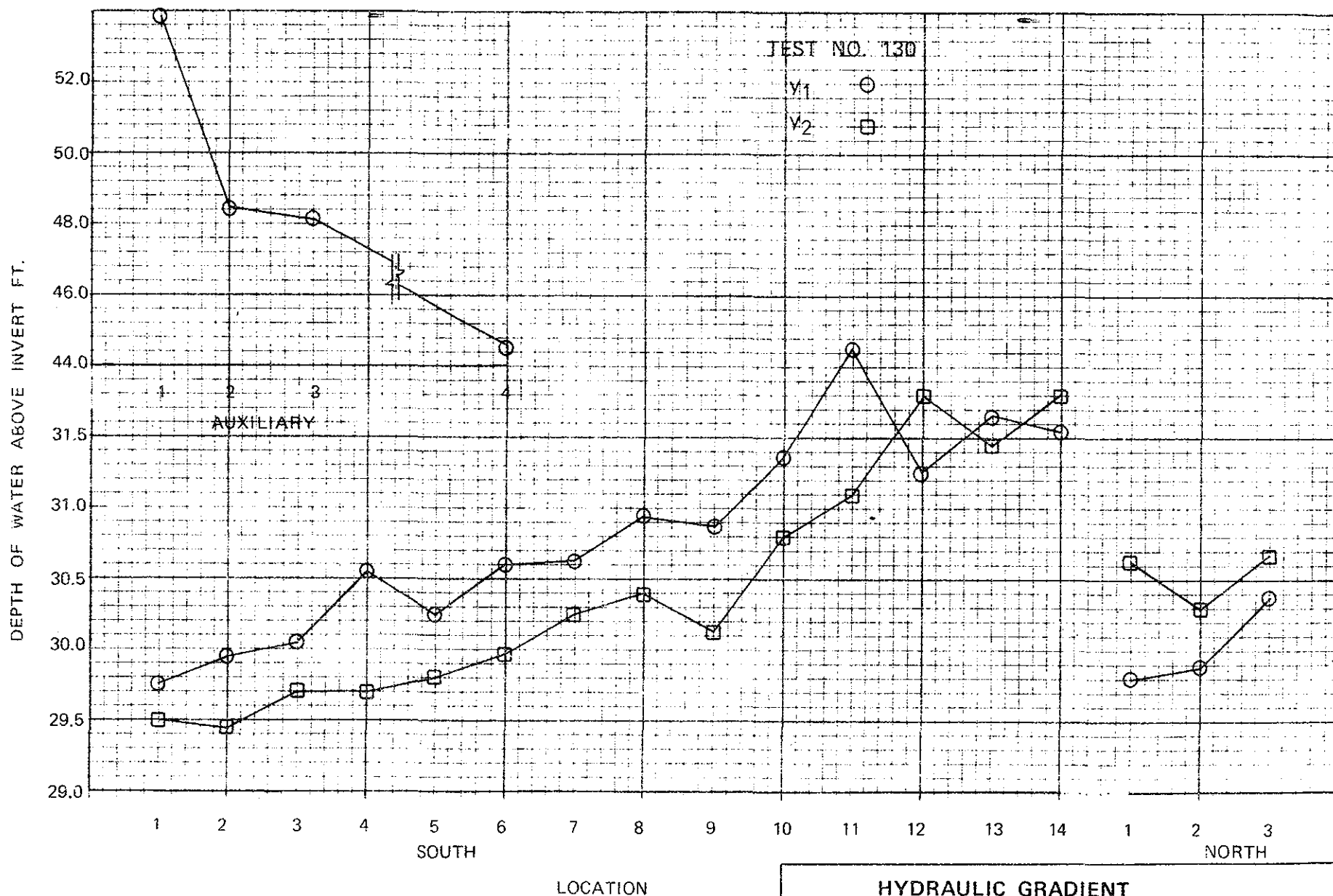
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DEPT. OF ARMY CORPS OF ENGINEERS

MARCH 19, 74

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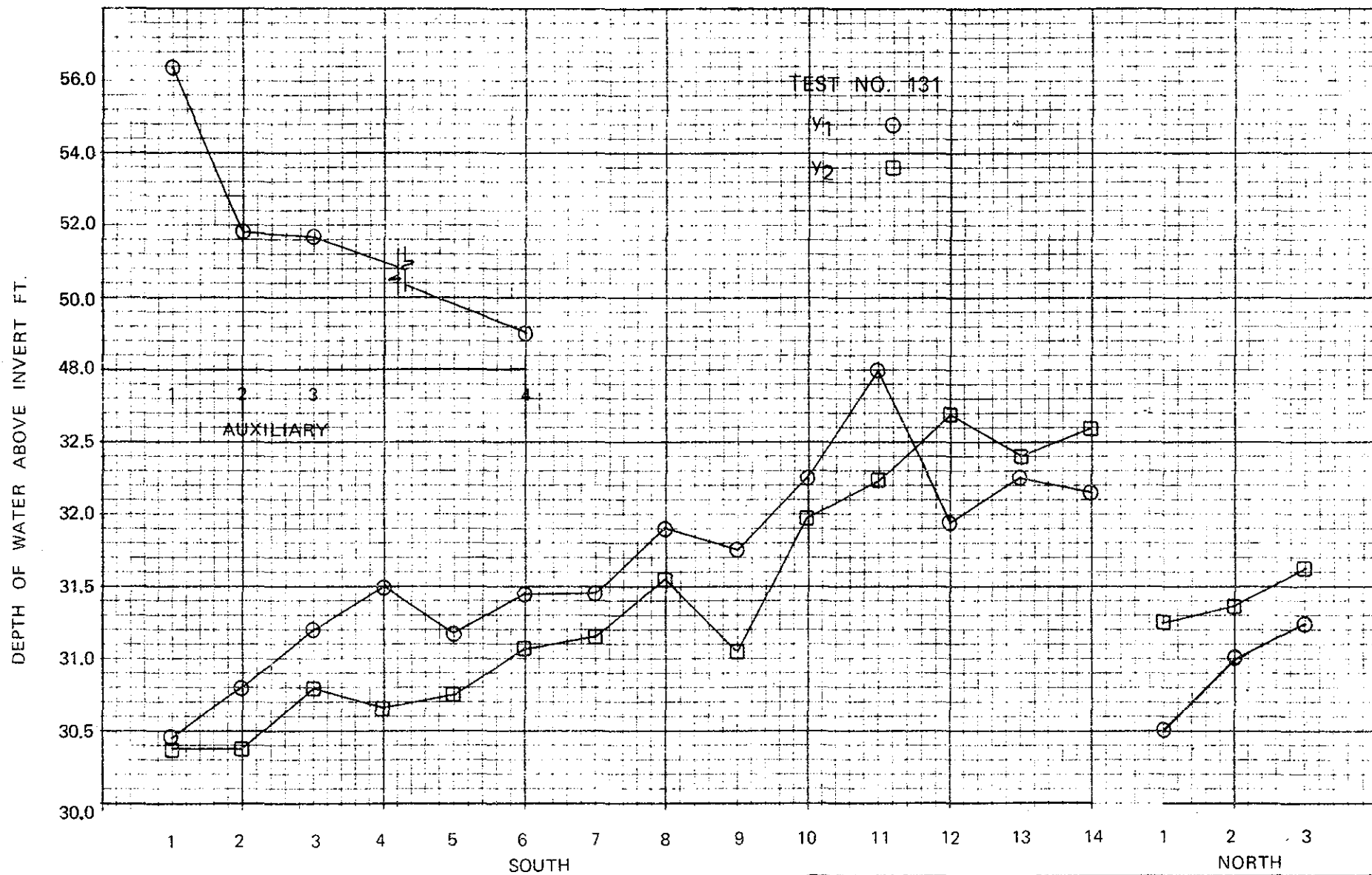
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LOCATION

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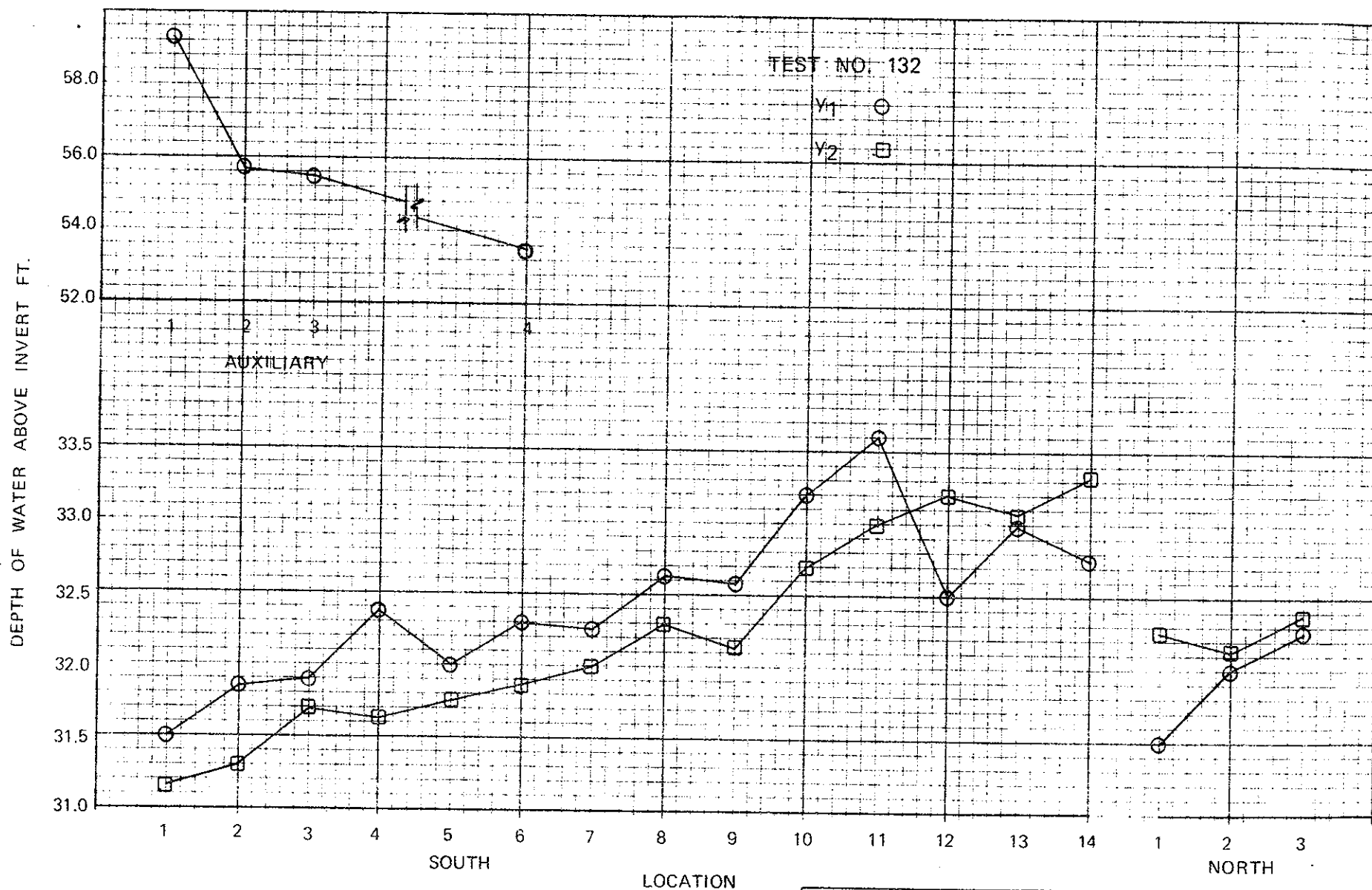
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